FIRST PRINCIPLES OF AGRICULTURE

GOFF & MAYNE

AMERICAN BOOK COMPANY

FIRST PRINCIPLES

OF

AGRICULTURE

BY

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INTRODUCTION

BY

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PREFACE.

The great importance of the practical element in education has gained almost universal recognition during the past few years, and to-day educators are practically unanimous in emphasizing its necessity. Both from utilitarian motives and in recognition of the value of applied knowledge as a disciplinary study, they are urging the introduction of studies which pertain to the life and environment of the child. The mental exercise or discipline derived from such studies is much greater than is usually accredited to them, as the material of study is ever present, constantly stimulating the mind to activity.

The latest demand is for the introduction of the Principles of Agriculture in the rural schools. There are special reasons for the introduction of this study. The education of the country boy and girl has been "away from the farm and toward the factory" and the city. The study of civics, of geography, of history and of biography has created ideals of greatness that find their expression only in city life. Even the so-called "Nature Study" has been largely sentimental and urban in its leanings. The result has been a continual and constantly increasing exodus of the most thoughtful and enterprising young men and young women of our rural districts to the city. The introduction of the study of the Principles of Agriculture in the rural schools proposes to make the *farm* the center of interest and to make all its

industries, its economies, and its science the subjects of thought and study. Many of our best sociologists look to the introduction of the study of agriculture under favorable circumstances as the most helpful agency in securing intelligent management of our farms.

Many books have been prepared whose object is to furnish a text-book in elementary agriculture for the use of pupils in the rural schools. That these books have lacked adaptability for the purpose intended is evident from the insistent demands for a text-book, which, while it shall not be too difficult for the boys and girls in the rural school of to-day, shall yet cover pretty thoroughly the numerous departments of our complex agriculture.

The constant ideal in the minds of the authors was the production of a book on this subject that shall be simple enough to be placed as a text in the hands of the pupils in the upper form of the rural school. Many things have been omitted that to others may seem essential in a book of this kind. The limitations in the size of the volume, as well as of the time of the pupil, led to the omission of many subjects that would be very interesting and profitable, but concerning which special treatises should be consulted.

The French Minister of Education, in giving instructions "to assist the masters of rural elementary schools in teaching the first rudiments of agriculture," says: "Instruction in the elementary principles of agriculture, such as can be properly included in the programme of primary schools, ought to be addressed less to the memory than to the intelligence of the children. It should be based on observation of the every-day facts of rural

life, and on a system of simple experiments appropriate to the resources of the school, and calculated to bring out clearly the fundamental scientific principles underlying the most important agricultural operations. Above all, the pupils of the primary school should be taught the reasons for these operations, and the explanations of the phenomena which accompany them."

The first part of the book is based upon experiments which may be performed in the school room or at home. A summary, entitled "What We Have Learned," has been placed at the close of each chapter. These summaries furnish definite statements for the pupil to learn, and may be used by the teacher as a basis for drill work.

This plan has not been pursued in the latter part of the book, because the subjects considered do not lend themselves easily to the experimental method of treatment. Numerous illustrations have been given, however, and it is hoped that the teacher will combine observation exercises on the farm with the work in the school.

The preparation of this book was begun by E. S. Goff, late Professor of Horticulture in the University of Wisconsin. Professor Goff had many years of experience in teaching the principles of agriculture to young men, and, as a careful investigator and student of agricultural subjects, he achieved a national reputation. It is greatly to be regretted that his death in the summer of 1902 prevented him from completing a work that had so much of promise in it. Although I was in frequent consultation with him during the preparation of the manuscript, and although I have striven to complete the work

in accord with his plans and outlines, I alone am responsible for its shortcomings and whatever virtues may inhere in it are attributable entirely to him.

It gives me pleasure to acknowledge the work performed by Miss Devlin, of the Whitewater Normal School, in testing the experiments in her classes and in giving valuable suggestions in the preparation of the manuscript.

I am under great obligations to several members of the Faculties of the Agricultural Schools connected with the University of Wisconsin and the University of Minnesota for valuable criticism and suggestions.

D. D. M.

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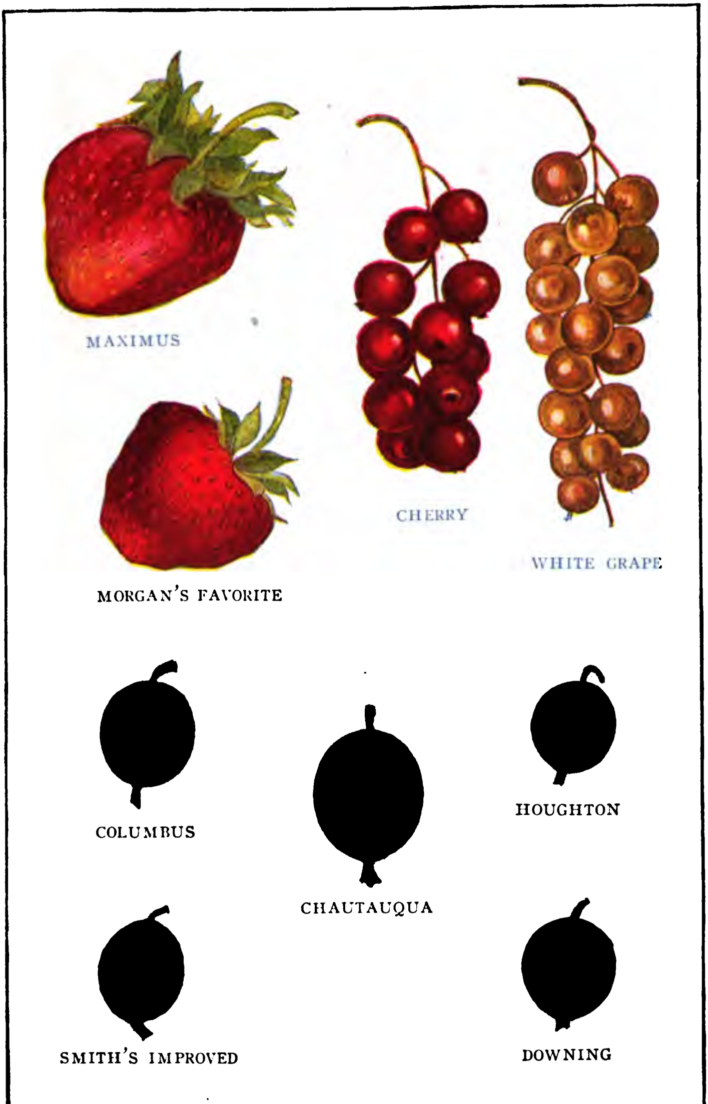

STRAWBERRIES GOOSEBERRIES CURRANTS

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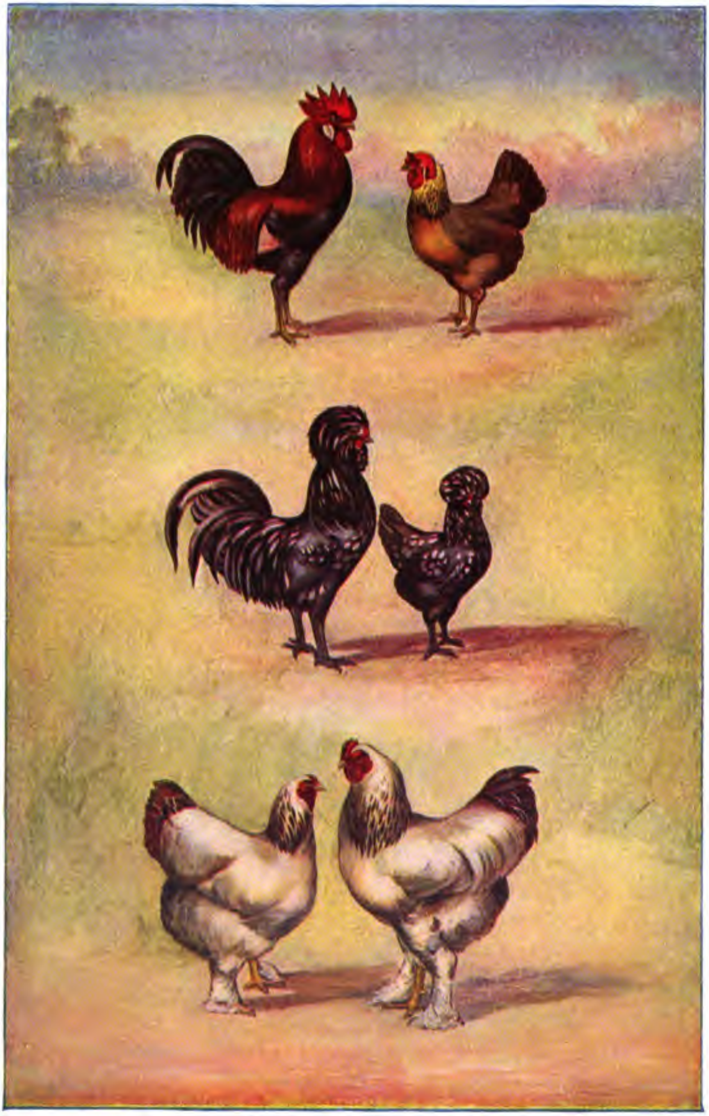

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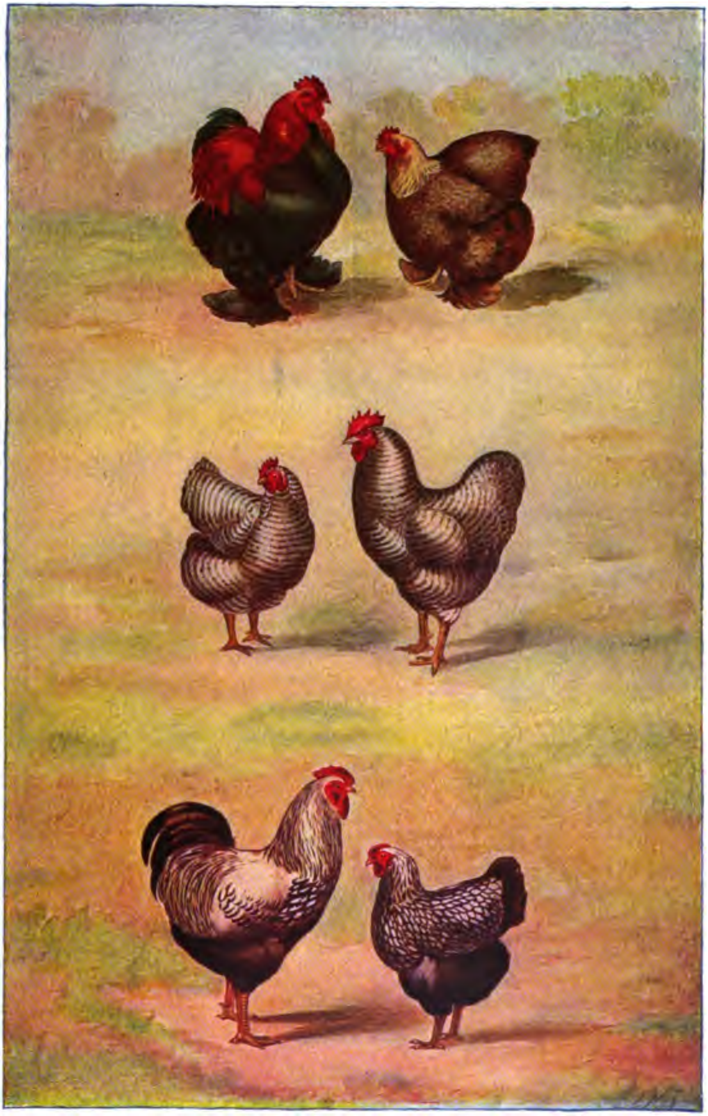

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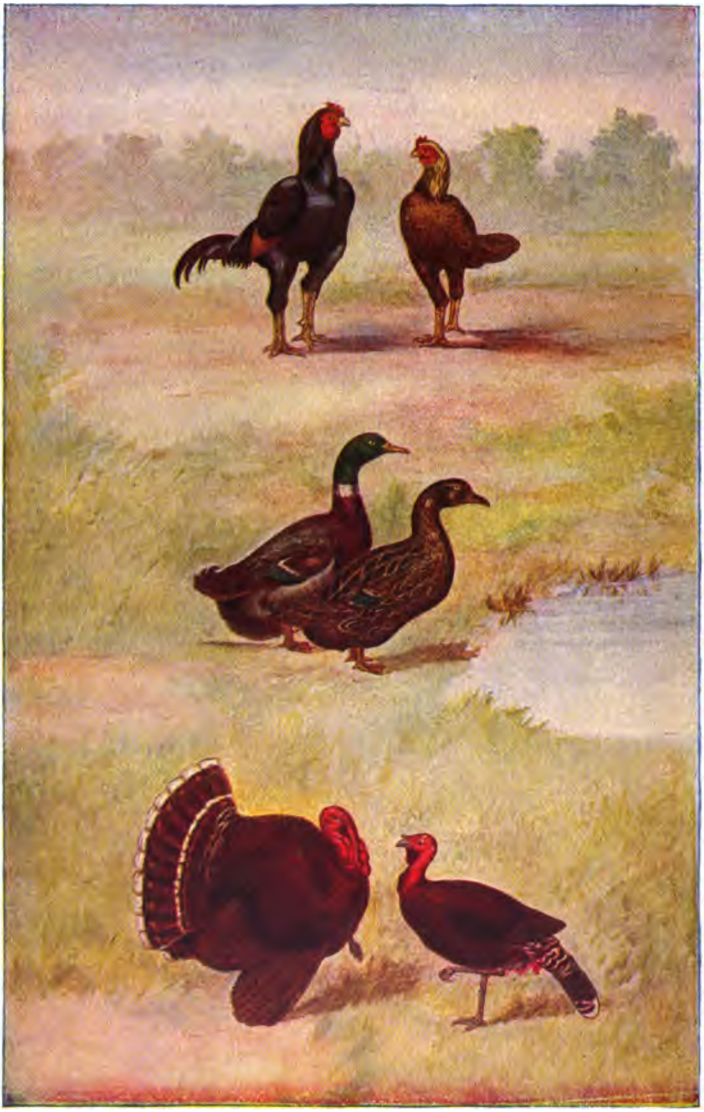

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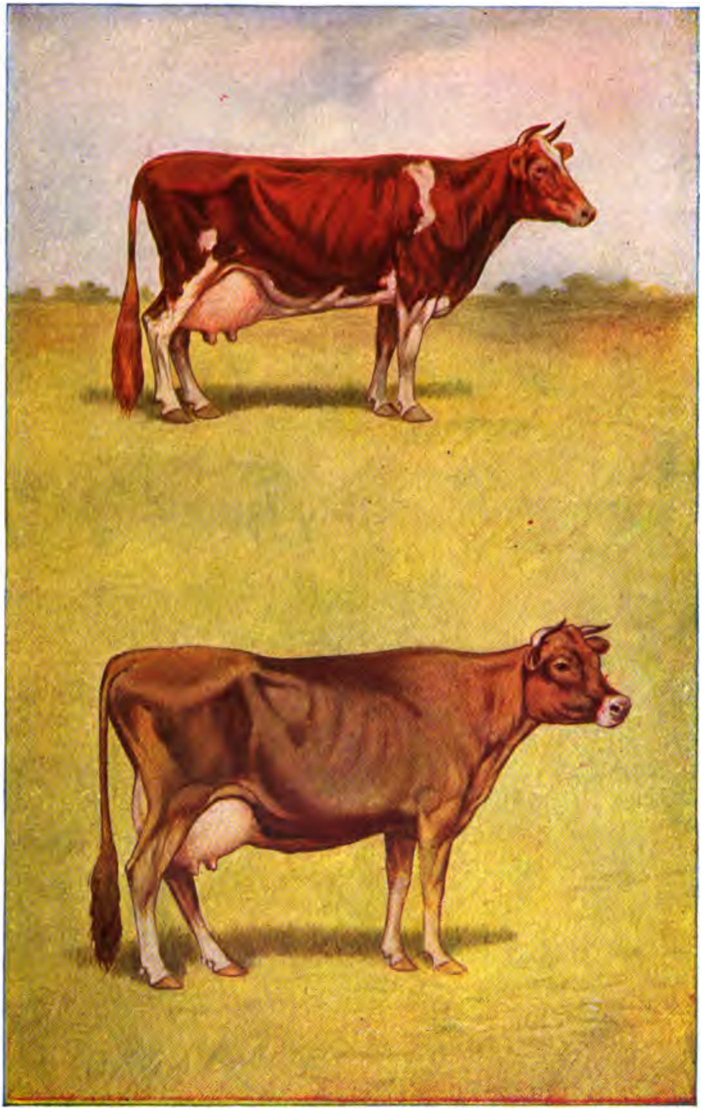

GUERNSEY COW (above) JERSEY COW (below)

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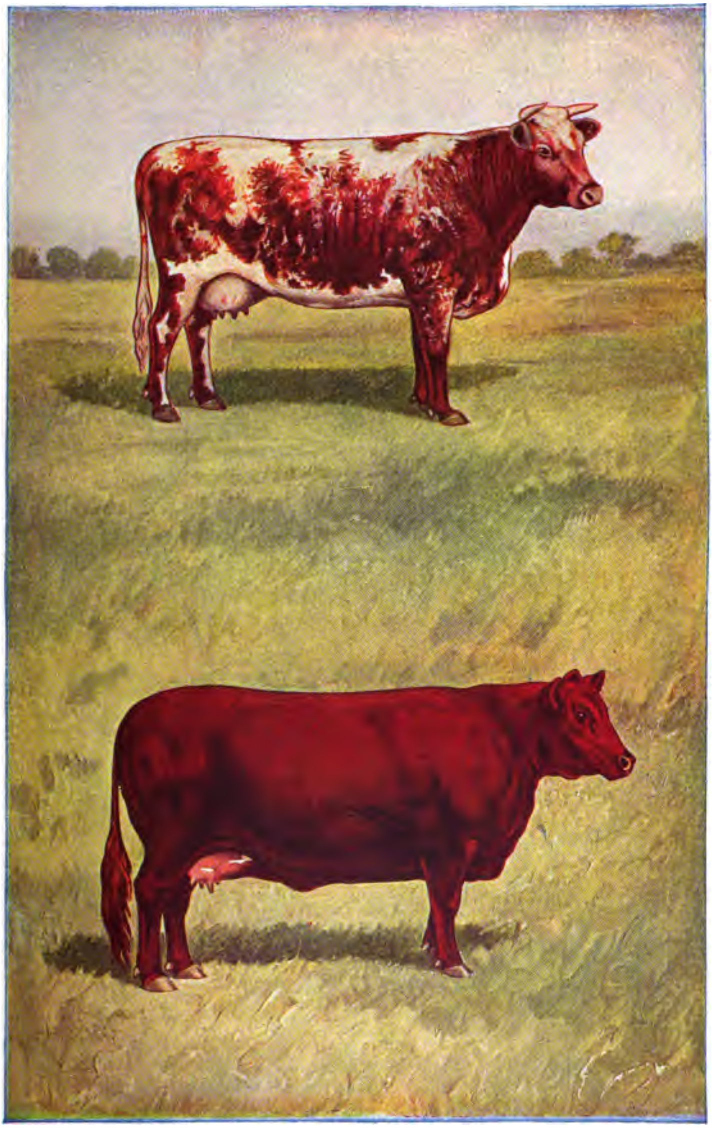

SHORTHORN COW (above) RED POLLED COW (below)

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INTRODUCTION.

A few years ago, I was present at the meeting of the State Board of Agriculture in New Haven, where a college professor gave an address on Botany. The address was scholarly, scientific, and thoroughly interesting, but it gave no particular aid or help to a better understanding of the problems of vegetable life that confront the farmer. When the speaker was through, I asked him why it was that all the botanical wisdom of the world had not constructed a simple, clear, easily understood text-book for schools and farmers on Farm Botany. I stated the great need of such a book, and gave the following illustration: There are two important laws that govern the growth of the red clover plant, which, if understood by the practical farmer, would prove of incalculable value to him. The first is that the plant, being a biennial, proceeds to die when once it has produced seed. The bearing of that law on the farmer is this: He allows his clover to advance so far in growth before he cuts it that the seed is formed. Cut it before seed forming, and Nature, thwarted in her purpose, will rally all her forces and throw a vigorous second crop; cut this before the seed forms, and she renews her efforts with the same persistency for a third crop. In this way, the farmer, *if he knows the law,* can take advantage of it to his greater profit. Allow the seed to form, and the plant is then through with its maternal purpose, which is the object of its life, and but

a very light second crop can be grown. This law applies to alfalfa as well. Delay the cutting of the first crop too long and the second crop will be very light.

Take the second law: For years the farmers of the United States have suffered untold loss through the dying of their newly seeded clover. When sown with a grain nurse crop, the clover would germinate and make a fine stand if sown with oats, for instance, but, when the oats were harvested, the young clover plants would be burned to death. I noticed, however, that, where a farmer had a field of oats, that was seeded with clover, near his barn, if he cut into it, when the oats were green, to feed his horses or to soil his cows, the young clover plants in that part of the field always lived and survived the summer heat. I observed, also, that, where a farmer cut a swath around the outer edge of his oat field about two weeks before the oats were ripe that he might have a clear space on which to turn his reaper and team, there, also, the clover survived. I reasoned from these observations that there was something in the growth of the oats and clover together that acted disastrously to the young clover plants. It took me a long time to find the botanical fact, so stated that an ordinary man could understand it that oats require five hundred pounds of water to ripen one pound of the grain. I then saw that, with this tremendous drainage of moisture from the soil in consequence of the ripening of the grain, together with the evaporation by sun and wind, the young clover plants could not live; but that, when the oats were cut before the grain formed, the clover could live.

I asked the professor: "Is there anything to hinder

these two important biological facts bearing on the clover plant being put in a text-book and taught to the farmer's boy?"

The professor did not answer these questions very satisfactorily.

I have been pushing along this road for years, striving to have the elements of agriculture taught in the common schools of my own state, Wisconsin. I have seen something done. No teacher is now allowed to graduate from our Normal Schools until he or she has taken a course in Elementary Agriculture. Furthermore, we have established several County Training Schools, whose particular function is to educate the teachers of the country schools for the teaching of Elementary Agriculture. We have also begun the erection of County Agricultural Schools which take the country farm boy and give him instruction something like that now given in the Short Course of our Agricultural College. France, Germany, and, indeed, nearly all Europe, are doing this work of teaching Elementary Agriculture in the primary schools. These nations are fifty years ahead of the United States in their comprehension of how it is to be done and in the doing of it.

As a people, we have gone mad in our pursuit of so-called "higher education." Rightly understood, there is no such education. A better term would be "wider education." Our teachers, even in the country district schools, unwittingly educate the farm boy and girl away from the farm. If they seek to inspire in them ambition in the pursuit of knowledge, it is for the purpose, as they say, of encouraging them to "rise in the world." What

American agriculture needs more than anything else is that it become intellectualized, that it be made the purpose and object of mental, as well as physical, effort. Its greatest reward as to wealth, honor and contentment lies in that direction. It must be made the object of brain work as well as manual work. To bring about this attitude, we must take hold of the children of our farmers in their home schools, and there show them that the problems of the farm are great enough to enlist all the brain power they can summon. Once there is established in the mind of the farm boy an intellectual insight into the problems of the farm, the future of better farmers, better farms, and a wider, stronger conservation of the resources of the state, will be established. It seems to me self-evident that, if we are to reach this great body of men, in whose hands lie the destinies of all future agriculture and, to a great extent, the weal of the whole country, it must be through the schools in which and in which alone they receive their education.

W. D. Hoard.

FIRST PRINCIPLES OF AGRICULTURE

1. DEAD AND LIVING MATTER.

Illustrative material: A few grains of sand on a piece of paper. Examine the grains carefully.

Dead Matter.— Figure 1 shows a grain of sand as it appears under the microscope. Its corners have been rounded by rubbing against other grains of sand. It can not move; it can not change its form. We might leave it under the microscope and look at it daily for a year, and it would look just the same every time. It never grows larger and never divides into other grains of sand unless it is broken by some outside force. It has no life; it is *dead.*

FIG. 1.—Grain of sand, magnified.

Living Matter.—Figure 2 shows some yeast plants as they appear under the microscope. The yeast plant is so small that it can be seen only with a microscope. Each yeast plant consists of a closed sack or cell, containing a jellylike liquid called *protoplasm.* If we watch the yeast plant under the microscope, we find that it changes in form. Sometimes little swellings grow

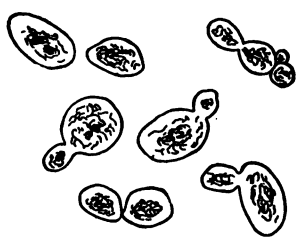


FIG. 2.—Yeast plants, magnified.

out, like knobs on a potato, and these will by and by separate themselves from the parent and become other yeast plants. The yeast plant is *alive;* so is every growing plant.

The Ameba.— Figure 3 shows several specimens of the ameba, an animal found in stagnant water. It is so small that it can be seen only with a microscope. The ameba consists of protoplasm; it can move itself about; it can change its form; it can divide and so make other amebas. The ameba, like the yeast plant, is alive. Plants and animals have life. Sand and all other mineral matters are dead. Plants and animals may lose their life, and then their bodies, like mineral matter, are dead.

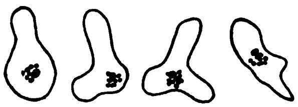


FIG. 3.—Amebas, magnified.

Plants and Animals Grow.— If we put a drop of fresh yeast into a bottle containing well water with some sugar and a little white of egg stirred into it, and set the bottle in a warm place, in a few hours the liquid will become whitish in color. This is because millions of new yeast plants have formed from the few we put in. The young yeast plants and amebas are at first small, but they grow until they are as large as their parents. Plants and animals increase in number, and grow in size. Dead things can not, of themselves, grow or increase in number.

Cells.— Figure 4 shows a small part of an apple leaf, as it appears under the microscope. Notice that it is made up of many small sacks grown together. Each of these little sacks is a cell, something like a yeast plant.

A plant large enough to be handled is made up of a multitude of cells grown together, each of which is, or has been, alive. An animal large enough to be seen without a microscope is also made up of many living cells, each of which is like the ameba in many respects.

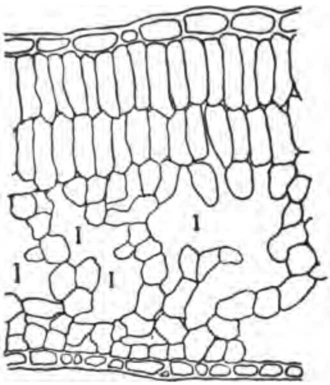


FIG. 4.— Showing cells for the apple leaf in a section from its upper to its lower surface. Highly magnified. The spaces marked I are cavities between the cells.

Needs of Plants and Animals.— Plants and animals need certain things to keep them in health. Protoplasm, which is the living part of cells, must have both food and water, or it can not live long. In all the higher plants and animals, it must have air, or it will smother; it must receive a certain amount of warmth, or it will either freeze to death or cease to grow; and the protoplasm in certain cells of the higher plants must have light, or the plants will soon die. To keep plants and animals healthy, we must provide them, as far as possible, with any of these things that they lack.

Produce.— The farmer rears plants and animals. He rears plants on his land, and his animals feed on the plants. Plants and animals reared on the farm are called *produce.* The farmer sells a part of his produce to those that need it, and thus secures the means to buy clothing and tools, to erect his buildings, to improve his home, and to educate his children. His soil is formed

of mineral matters and the dead remains of plants and animals. The farmer needs to learn all he can about the soil, and how plants and animals grow. He should also strive to learn what crops are likely to repay his labor best, and how to dispose of these to the best advantage of himself and his farm.

WHAT WE HAVE LEARNED.

Plants and animals are living beings. They are made up of cells.

The simplest plants and animals are made up of single cells.

All living cells contain protoplasm.

The soil is largely dead mineral matter.

The farmer should learn all he can about the plants and animals he rears, about his soil, and about his crops and markets.

2. THE SOIL AND SOIL WATER.

Illustrative material: An oil lamp, a narrow-neck bottle, two other bottles, and some candle wicking.

Prepare the soil lamp, Figure 5, by filling a small, narrow-neck bottle about one-third full of kerosene oil, and then filling the bottle to the top with small fragments of dry earth. If the oil does not saturate the earth to the top, add a little more oil.

Prepare the experiment shown in Figure 6, using a small lamp wick or candle wicking. Add water to the left hand bottle, and wet the wick before putting it in place.

Oil and the Lamp Wick.— In a lighted oil lamp, the oil passes upward through the wick as fast as it burns. The oil passes through the wick because the wick contains a number of small spaces or pores that connect with one another. It would rise through almost any very porous substance as a sponge, a piece of blotting paper, a piece of brick, or of porous earth.

FIG. 5.—Earth lamp.

Dry Earth as a Wick.—Figure 5 shows a lamp made of a bottle filled with dry earth, which answers for the wick. The oil rises through the earth because the earth is porous. It creeps from one particle of the earth to another at the points where the particles touch one another. The larger the particles are, after they pass a certain size, the slower will the oil rise, because the points where the particles touch are fewer.

Capillary Attraction.— Water also will rise through a lamp wick or other porous substance. In the experiment shown in Figure 6, the water passes through the wick from the left bottle into the right one. If the bottle contained porous soil, as in Figure 5, the water would rise through the soil to the top of the bottle, where it would slowly pass off into the air. The force which causes oil, water or any other liquid to rise through a porous substance, is called *capillary attraction* or *capillarity*.

Fig. 6.—Illustrating capillarity.

Evaporation.— If we rub the blackboard with a damp cloth, the board does not remain wet long, because the water passes off into the air. We hang wet clothes upon a line so the water in them will pass off into the air and they will become dry. The passing off of water from a wet surface into the air, we call *evaporation*.

Evaporation Rapid.— Water is evaporating from the soil out of doors nearly all the time when it is not raining; and, as in the lamp wick the oil rises from the font as it burns at the top of the wick, so the water rises from the deeper soil as it evaporates at the surface. In countries that have frequent rains, the water rises from below in dry weather nearly or quite as fast as it evapo-

rates, hence the soil is kept moist except at the very surface.

Water Not at Rest.— During rain, or whenever the surface soil is wetter than the soil below, the water passes down into the soil until it reaches a layer that it can not

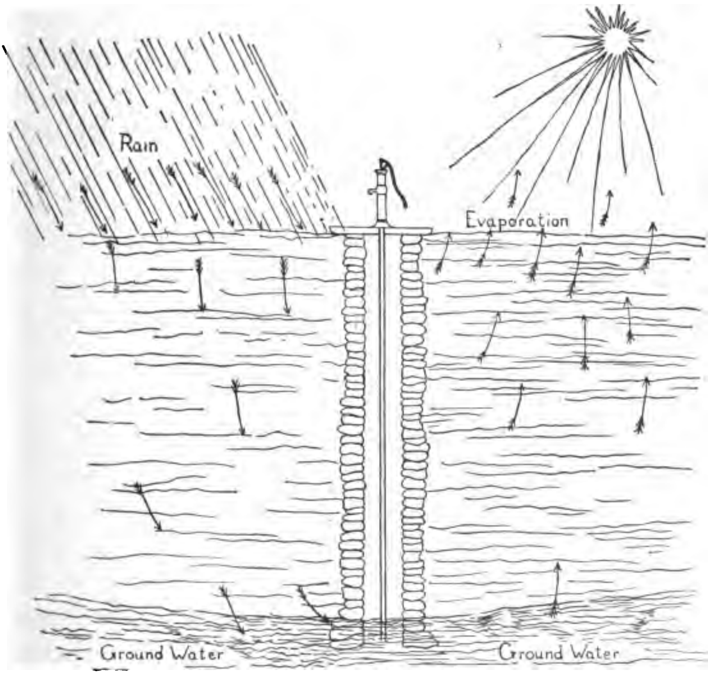


FIG. 7.— Showing the circulation of water.

pass, or until the upward current again begins; the water in the soil is seldom at rest. In many places, there is a surplus of water deep down in the soil, which flows into wells or flows out in certain places as springs.

WHAT WE HAVE LEARNED.

The rising of oil through the wick of a lighted lamp is due to a force called capillary attraction. The same force causes water to rise through the soil to the surface in dry weather.

The passing off of water from a wet surface into the air is called evaporation.

In dry weather, water evaporates from the surface of the soil, and other water from below rises to take its place. In wet weather, the water in the soil tends to move downward.

3. PLANTS AND WATER.

Illustrative material: A dried leafy shoot from some growing plant and three bean seedlings that have attained their rough leaves; two small bottles, one filled with water; a fruit jar.

Evaporation from Plants.— If we cut off a leafy branch from a growing plant and put it in a warm oven, the leaves and stem will soon become much smaller and lighter and more brittle. This is because the water which the branch contained has been evaporated by the heat. Often more than four fifths of the weight of a growing plant is water. Hay is dried grass. The farmer cuts his grass and lets it lie exposed to the heat of the sun until most of the water it contained has evaporated.

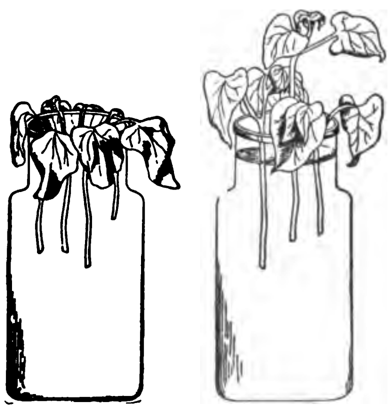


FIG. 8.— Plants need water.

Water Necessary.— If we cut off two bean seedlings at the surface of the ground and put the stem of one into a bottle of water and that of the other into an empty bottle, we shall find that the leaves of the seedling that we put in the empty bottle will soon droop, while those of the other will remain fresh. (Figure 8.) This experiment teaches some important things about plants. First, it

shows that the leaves of plants growing in a rather dry atmosphere must have a constant supply of water, or they can not remain fresh. Second, it shows that the water is taken in through the stem. Third, it shows that, in uncut plants, the water must come into the stem from the root, because our stems were cut at the surface of the ground.

Evaporation through Leaves.— If we fill two bottles of the same size with water, and insert in the neck of one of them several small twigs from a growing plant, we shall find that the surface of the water will lower much faster in the bottle containing the twigs than in the other bottle. Where has this water gone? If now we place a cool fruit jar over the twigs and hold it there a short time, we shall be able to answer this question. Water from the leaves will gather on the inside of the glass, so that we can easily see it. If we leave the jar over the twigs for half an hour, drops of water will flow down its inside surface. This shows that some of the water taken up by the roots or plants passes off, or *transpires,* through the leaves.

Fig. 9.— Leaves do not absorb water.

Leaves do not Take in Water.— If we take the fresh bean plant out of the water and put one of its leaves instead of the stem into the water, we shall find that the other leaves soon droop. (Figure 9.) This shows that the leaves of the bean plant can not take in much water, even when they are surrounded by it. The leaves of plants can not take in much water, either from water or from moist air.

Plants Dry the Soil.—Since plants require much water, and since their roots take this water from the soil, soil on which plants are growing dries much faster than the same kind of soil with no plants growing on it. The soil seldom contains water enough in dry weather to supply crops with all they need. Weeds waste valuable water in dry weather; so do the hedges of underbrush sometimes allowed to grow along fences. The farmer and the gardener should constantly study how to prevent the waste of soil water in dry weather. We shall learn how to do this in a later lesson.

WHAT WE HAVE LEARNED.

Growing plants consist largely of water.

This water is taken in by the roots and passes off through the leaves as vapor.

The leaves of plants can not take in much water.

The soil seldom contains enough water in dry weather to supply fully the needs of crops.

Weeds and useless underbrush waste valuable soil water in dry weather.

4. HOW PLANTS FEED.

Illustrative material: Dissolve a bit of camphor gum in a small bottle of alcohol; then pour a part of the solution into a glass sauce dish, and, when the alcohol has evaporated, show the recovered camphor. (If conveniences for boiling water are at hand, a solution of sugar in water may be used.)

Burn a little dry hay or straw on a plate, in the presence of the class, and show the ashes. Show also a bit of starch, and a piece of charcoal to illustrate carbon.

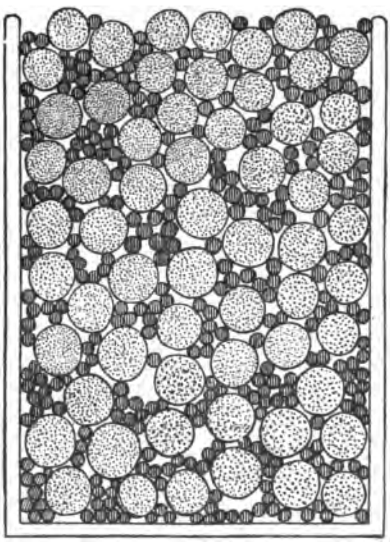


Fig. 10.— Diagram showing spaces between particles.

Solutions.—If we put a teaspoonful of sugar into a glass of water and then stir the water with the spoon, the sugar will soon pass out of sight. We say it has *dissolved* in the water. We explain its disappearance by supposing that it has separated into particles that are too small to be seen, and that these particles have entered among the particles of the water, something as a quart of peas might be poured into the spaces between apples in a peck measure. (Fig-

ure 10.) If now we evaporate the water from the glass, the sugar will again appear in the bottom.

Mineral Matter in Plants.—A tea-kettle in which well water is often boiled usually becomes coated inside with a whitish deposit. Well water contains small quantities of certain mineral matters dissolved in it. When the water evaporates from the tea-kettle by boiling, these mineral matters remain in the bottom, just as in our experiment the sugar remained in the basin after the water evaporated. We learned in Lesson 3 that plants take up water, and that this water passes off as vapor from the leaves. The water thus taken up by plants comes out of the soil and so has certain mineral matters dissolved in it. When this water is transpired from the leaves, the mineral matters remain, just as they remain in the tea-kettle when the water evaporates from it. Some of these mineral matters are required by the plant for food. Aside from water, the roots can take only dissolved substances.

Other Matter in Plants.—We have now learned how plants secure the mineral part of their food. But are plants formed entirely of mineral matter? We can answer this question by a simple experiment. Mineral matter will not burn. If we burn a little bunch of hay or straw, the part that will not burn, the ashes, is mineral matter. The ashes of the hay were brought up from the soil in the water that was taken up by the grass roots. When we burn a substance, we separate it to some extent into the parts that once came together to make the substance. Nearly all of the part of the hay that passes off into the air in burning came out of the air while the grass was growing.

Carbon from the Air.— It seems strange that a part of the grass could come out of the air. We can see the mineral matter left in the bottom of the tea-kettle, and so can easily believe that the soil water contains mineral matter. But we can not see the air, and it is hard to understand how matter can come out of the air to make a plant that we can see, handle and weigh. But, just as the soil water has solid mineral matter dissolved in it, so the air has a gas called *carbonic acid* mixed with it. This gas is formed of two substances: carbon, which is a solid that we can see and handle; and oxygen, a gas that we can not see. When the oxygen is taken out of the carbonic acid, the solid carbon is left, just as when the water is taken out of the sugar solution the solid sugar is left.

Chlorophyll with the Sun making Starch.—The carbonic acid enters the leaves of plants through very small openings. It then enters the cells and comes in contact with a substance called *chlorophyll,* which the cells of leaves contain. Here a wonderful change takes place. When the sun is shining, the carbonic acid and a part of the water that the cells contain are *decomposed,*— that is, they are separated into the parts that form them. Some of these parts, including the carbon, then unite again and form a new substance that is very different from either the carbonic acid or the water. This new substance is starch, or something of very similar composition. (Figure 11.) It may be formed in any part of the plant that is green,— that is, in which the cells contain chlorophyll. But it is formed chiefly in the leaves.

Food of Plant Made in Leaves.—This starch or like substance formed in the leaves, together with some of the mineral matters brought up in the soil water, serves as food for the protoplasm of the cells, so that the cells

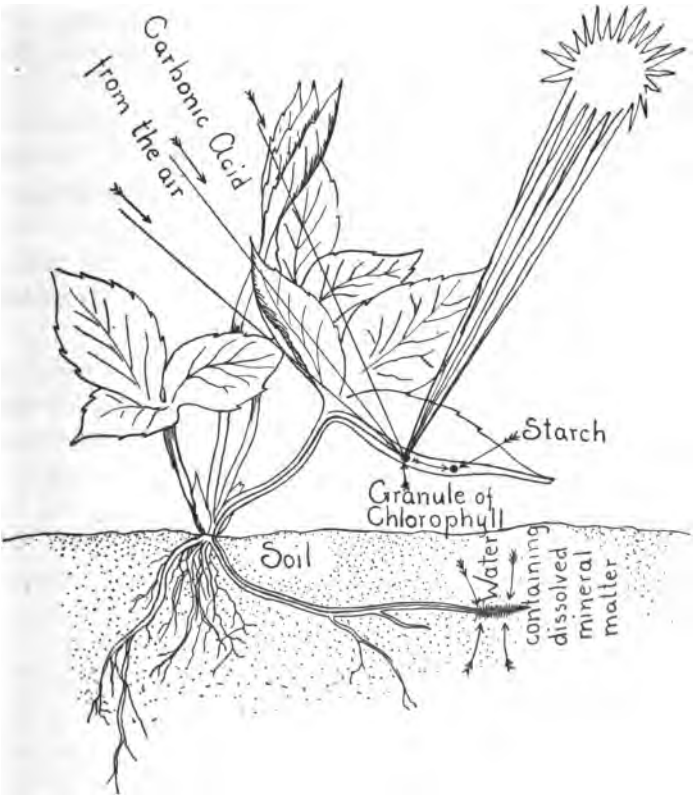


FIG. 11.— Illustrating the formation of starch.

increase in number rapidly and thus cause the plant to grow. The cells in all parts of the plant, including the farthest root tips, are fed by this leaf-formed food. It

follows that the health of the plant depends upon the health of its leaves.

WHAT WE HAVE LEARNED.

Certain substances may be dissolved in water. By evaporating the water the dissolved substances may be recovered.

Soil water has certain mineral matters dissolved in it. These enter the roots of plants with the soil water. When the water passes off by transpiration, these mineral matters remain in the leaves.

When we burn plant or animal substance, the ashes show merely the part that came from the soil. The rest came from the air.

Carbonic acid and water are decomposed in the green leaves of plants by the action of sunlight. Some of the parts unite again to form starch, or a similar substance, which nourishes the cells and causes the plant to grow.

Without healthy leaves a plant can not do well.

5. HOW PLANTS GROW.

Illustrative material: Specimens from parts of living plants illustrating the root, stem, buds, leaves, flowers, and fruit or seed.

Root Downward, Stem Upward.— Figure 12 shows a young plant of Indian corn. It grew from the kernel to which it is attached. Two tiny shoots grew from the kernel. One of these grew down into the dark, damp soil to become the root; the other grew up into the light to become the stem. Every seed when it *germinates,*— that is, when it begins to grow,— sends out two shoots, one of which tends downward, and the other, upward. During the life of the plant, the stem and root that start in the seed normally continue to grow by the division and growth of certain groups of cells near their tips.

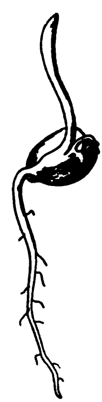


FIG. 12.— Plantlet of Indian corn.

Root Hairs.— Figure 13 shows some very young radish plants that were grown in a seed tester. Notice that each tiny white root that grew from the seed is clothed with a downy fringe that looks like the finest silk. These delicate fibers are called *root hairs,* and they take up water for the plant. The young roots of most plants are clothed with root hairs. These draw in water from the soil with a certain amount of force. This force, aided by some other forces, causes the

water to rise through the stem and to supply all the cells with water and with food.

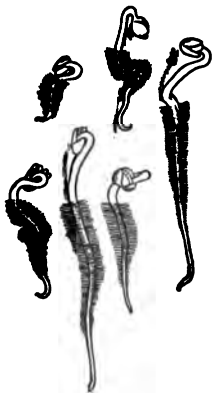


FIG. 13.— Young radish plants.

The Stem.—The stem bears the leaves, buds, flowers, and fruit or seeds. In upright-growing plants, the stem supports these parts at some distance above the earth; sometimes, as in the grape-vine, the stem climbs upon other objects for support; sometimes, as in the melon, it creeps on the ground; in other plants, as the potato and quack grass, it may even grow in part underground. (Figure 14.) As we have learned in Lesson 3, the stem is the channel through which the food prepared in the leaves passes to the roots.

The Leaves.—The leaves grow out from the stem at regular places. If we hold a leaf toward the light, and place a finger behind it, we find that the light can pass through the leaf. As we learned in Lesson 3, the sunlight shinning through the leaf cells prepares the food for the cells of the whole plant. The cells of the leaf are arranged in thin plates to expose a very large number of them to the action of the sunlight. (See Figure 11.) The leaves look green because their cells contain green chlorophyll. But the cell walls of the leaves are transparent as glass.

Leaves Necessary.—We learned in Lesson 4 that the health of the plant depends much upon the health of its leaves. If insects eat the leaves, or if the leaves are picked off or broken, they can not prepare food, and

the cells of the root will not be so well fed; then the root can not grow so fast, and so can not absorb so much water for the leaves, so the whole plant must grow more slowly. If, from any cause, the leaves do not receive their full share of sunlight, they can not prepare their amount of food, and the plant will suffer. The leaves of our plants should be protected from harm as far as possible.

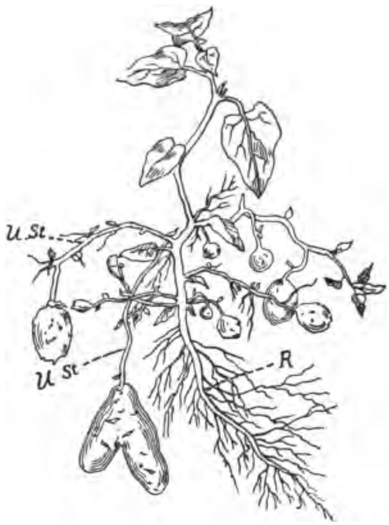


FIG. 14.—Potato plant. U. St., underground stems. R, roots. The tubers are the thickened ends of the underground stems. Much reduced. (After Frank and Tschirch).


FIG. 15.—Buds.

Buds.— Every live part of a stem terminates in a *bud*. (Figure 15.) If a part of the stem is growing, the bud at its tip is not well defined. But on stems that live through winter, when growth ceases, the buds are covered with scales, which usually render them easily seen. Buds inclosed in scales are called *dormant buds*. In woody stems, a dormant bud commonly forms in summer just above the base of each leaf. When the leaves drop in autumn, the buds remain. On the return of spring, they expand into new leaves or sometimes into flowers. The bud at the end

of the branch is called the *terminal bud*. This usually expands first. It either forms a flower, and dies, or it continues the growth of the stem. The *lateral* (side) *buds*, if they expand, either open into flowers, and die, or they develop into branches.

Seeds.—In plants that live through winter, the flowers are commonly formed in the buds the season before they expand. Many flowers are among the most beautiful and fragrant of natural objects. They delight us with their colors, their perfume, their freshness, their delicacy, and their graceful forms. But the flowers have other uses than to please the senses. By means of their flowers, plants are able to form the fruits and seeds we prize so much for food. Without seeds, many kinds of plants would soon pass away, for there would be no more little plants to take the places of those that die.

WHAT WE HAVE LEARNED.

The germinating seed sends out two shoots. One of these aims downward to become the root; the other aims upward to become the stem.

The root fixes the plant in the soil and supplies it with water and a part of its food. Roots can not live without air.

In the potato and some other plants, a part of the stem grows underground.

The live terminus of the stem is called the bud. In plants that live through winter, the buds are covered with scales as growth ceases.

In plants that live through winter, the flowers are commonly formed the season before they expand.

6. THE IDEAL SOIL.

Illustrative material: Jars or boxes containing black garden loam, clay, and sand. Mix a small proportion of sand with the clay to make a clay loam. Mix a large proportion of sand with the clay to make a sandy loam. Pour water on each kind of soil, and have the pupils note how rapidly it soaks through in each case and also the effect after it has dried.

Soil a Reservoir for Water.— We learned from Lesson 3 that plants transpire much water from their leaves, and that this water is taken up by their roots. The roots must get from the soil as much water as they need or the plants can not thrive. The soil receives its water from rains and snows, and these at irregular intervals. The ideal soil, therefore, must serve as a reservoir to receive and hold enough of the rain and the snow water to supply the needs of crops.

Soil Must Be Porous.—We learned in Lesson 4 that living cells require air as well as food. The live roots of plants consist of living cells, not one of which can live long without air. The ideal soil must, therefore, be porous enough to admit all the air the roots require. Rootlets will not grow into clumps or clods that are so compact that air can not enter them. It seems strange that the soil can supply the roots of plants with both water and air at the same time. A soil in proper condition for the rapid growth of roots may be compared to a wet sponge with air circulating through its pores, while the substance of the sponge contains much water.

Air and Water in Soil.— Figure 16 will help us to understand how the roots of plants are supplied with both water and air. The roots of most farm and garden crops grow fastest just at the bottom of the layer of soil that is turned by the plow. The soil above this point is better supplied with air than that below, while the *subsoil,* which is the part below this point, is better supplied with water than that above. The place where the plowed soil rests on the subsoil is, therefore, best supplied with both air and water.

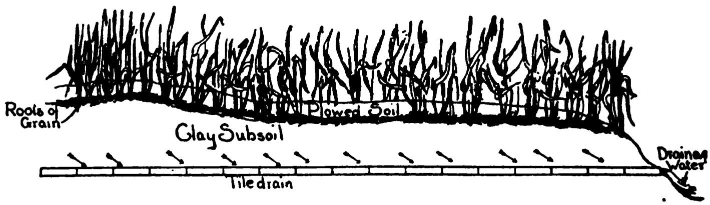


FIG. 16.—Water in the soil.

Loam.—Most farm and garden soils consist mainly of a mixture of clay and sand. Such a soil is called a *loam.* Sandy loams contain more sand than clay. Such soils dry rapidly. Clay loams consist mainly of clay. These retain water much better. The best soil for growing crops contains sand enough to let the surplus water move downward, and clay enough to hold sufficient water for the use of crops. Too much clay causes the soil to "bake,"— that is, to harden on drying. Soils inclined to bake may be improved by manuring, by the addition of sand or ashes, and sometimes by the use of lime.

Drainage Necessary.— If the pores of a soil remained filled with water a long time after rain, the air would be forced out and the roots of the crop growing on the

land might be smothered. The ideal soil must, therefore, be well drained, so that its pores will not long remain filled with water even in wet weather. This means that the subsoil must permit the surplus water to pass through it rather easily.

Tiling.—Soils over a subsoil containing too much clay dry out slowly in spring, and after heavy rains. Such soils may often be improved by *draining*,—that is, by providing ways for the surplus water to flow off. Ditches, connecting with an outlet on lower ground, may be dug through the land. Brick tubes called *tiles* are often buried in such ditches, and the surplus water flows out through these. (See Figure 16.) Sometimes brush or stones are used in place of tiles. Lands thus drained are often among the best for farming and gardening.

Plant Food in Soil.—We learned from Lesson 4 that, with the exception of carbon, the food of plants comes from the soil, and that it is dissolved in the soil water. If the soil does not contain food enough, the plants can not grow well, even though they have everything else that they need. The ideal soil must have sufficient plant food in a form that can dissolve in water to supply the needs of crops grown upon it. In the next three lessons, we shall learn about supplying the soil with plant food.

WHAT WE HAVE LEARNED.

The soil serves as a reservoir to catch and hold the water that falls in rains and snows, and to give it out as crops need it.

The soil should be porous enough to admit plenty of air to the roots of plants.

The soil is commonly best supplied with water and air at the bottom of the layer turned by the plow.

The subsoil should be well drained, so that the surplus water can pass down quickly.

The soil should contain enough plant food, in a soluble condition, for the needs of crops.

7. HOW TO KEEP THE SOIL FERTILE.

Illustrative material: Two jars or dishes, rain water, well water, two small pieces of gauze, and a few kernels of wheat. A small sample each of nitrate of soda (Chile saltpeter), phosphoric acid, and caustic potash. These may be purchased at a drug store, and illustrate common forms in which these substances are used by plants.

How to Make the Land Poor.— If we dissolve an ounce of sugar in a glass of water, and then dip out a teaspoonful of the solution, of course we take out a part of the sugar. We learned in Lesson 4 that plants take up soil water containing dissolved mineral matters. Now, if these plants are taken off the land on which they are growing, the soil can not contain so much soluble mineral matter as it contained before. If we continue to raise crops on the land, and to take them off and sell them without returning any soluble mineral matter to the soil, the soil will soon become "poor,"— that is, there will not remain enough of some mineral matters to feed plants well.

Certain Food Required by Plants.—When a painter wishes to prepare some paint to match a particular shade of color, he mixes a certain amount of paint of two or more colors; if he uses a larger or a smaller quantity of one of these colors, or if he adds another color he does not get the tint he desires. It is just so when Mother Nature builds up a wheat plant; she uses certain amounts of a definite number of materials from the soil, and can

not vary these amounts much, nor can she use one material instead of another. When the carpenters that are building a house run out of nails, their work must stop until more nails are provided; or, if they try to make their nails hold out by using less than the usual number, the house will not be strong and may be blown down by the first hard wind. Just so, if one of the soil materials that go to make up a plant runs short, the plant must stop growing, or the growth made will be unhealthy, and the plant will fail from disease.

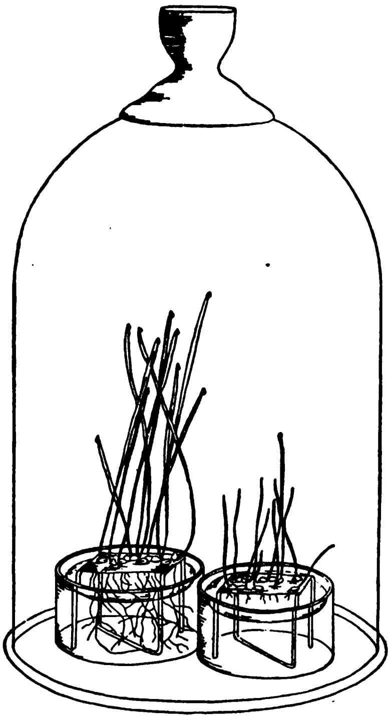


FIG. 17.— Plants growing in water.

Soil Water Holds Plant Food.— Figure 17 shows some wheat plants growing in water in two jars. The right-hand jar contains rain water, and the left-hand jar contains well water,— that is, water that has come out of the soil. Rain water has almost nothing dissolved in it, because, when water evaporates into the air, the dissolved materials it contained are left behind. In this experiment,

the water in both jars was boiled before being put in. The rain water was boiled to drive off the gases it had taken from the air, and the well water was boiled to evaporate a part of the water and thus to make stronger the solution of mineral matters it contained. From the picture, we see that the plants in the jar containing the well water are growing faster than those in the other jar. This is because the well water contains in solution the materials that the wheat plant needs for food. The rain water, on the other hand, contains almost no food material. The only reason the plants can grow in the rain water at all is that the seed contains a small amount of food. When this food is used up, the plants will soon starve.

Make-up of Rich Soil.— Chemists have found that certain quantities of about a dozen different materials are used by plants for food. The one that is used in largest proportion is carbon, and, as we learned in Lesson 4, this comes fom the air. All the others come from the soil. But of all the substances that come from the soil, only three often run short; most soils contain a large surplus of all the others. The three that often fail are called *nitrogen, phosphoric acid,* and *potash.* These are the only substances, then, that the farmer or gardener needs to put on his land often to keep it "rich,"— that is, to give it all it needs to produce good crops; and, since of these nitrogen is most often lacking, it must be supplied most generously to the soil.

Manure.—When plants of any kind grow on the land, they take out of the soil what they need for food. If we put these plants back on the land and let them decay,

they return to the soil the plant food they took from it in growing. Almost all plant material, therefore, is good to put on the ground to make it rich or *fertile.* Since animals grow by eating plants, or by eating other animals that grew by eating plants, most animal matter is also good to *fertilize* the land. *Manure,* which is decaying plant or animal matter from barnyards, stables, slaughter houses, etc., is the most common material used to fertilize the soil.

Wood Ashes.—Wood ashes contain the mineral matters that the trees from which the wood was obtained took from the soil when they grew. Wood ashes, therefore, are valuable for making the soil fertile. If they have not been *leached,*— that is, if they have not been exposed to water, they contain much potash and some phosphoric acid, but no nitrogen. If they have been leached, the potash has been mostly washed out.

Commercial Fertilizers.— In some parts of the world, deposits are found that are rich in nitrogen, in phosphoric acid, or in potash, and those materials are mined for fertilizers of the soil. Some manufacturing establishments have waste products that are useful as fertilizers. We can, therefore, buy fertilizers in the market as we can buy coal or lime. But *commercial fertilizers,* as such fertilizers are called, are rarely so cheap or so good for the soil as manure is, hence it is best for the farmer and gardener to depend, as far as possible, on manure to enrich their soil.

WHAT WE HAVE LEARNED.

Plants are formed of certain substances in nearly definite proportions. Other substances can not be substituted.

If one food substance in the soil fails, growth of the plant must cease, or, if the growth continue, it must be unhealthful.

Wheat and other plants can be grown in well water, as long as the water contains the necessary food materials.

About a dozen different substances are used by plants for food; but, of these, only three, nitrogen, phosphoric acid, and potash, are likely to fail in the soil.

Almost all plant or animal materials are good to use for enriching the soil. Unleached ashes contain much potash and some phosphoric acid.

Fertilizers may be purchased in the market, but the barnyard and stable manures are generally cheaper and more satisfactory than commercial fertilizers.

8. HUMUS IN THE SOIL.

Illustrative material: A small quantity each of clay, sand, and leaf mold. Swamp muck or dark-colored garden soil may be substituted for the leaf mold, if the latter can not conveniently be obtained.

Humus Defined.— If we dig up the ground at the bottom of a hollow in the woods where the leaves have gathered and decayed for centuries, we find the soil there very dark-colored and very porous. It is dark-colored because it consists almost entirely of *humus,* a substance that is always formed where vegetable matter decays in the soil. Humus is the vegetable or animal matter in which the process of decay is well advanced, but not complete.

Black Soil.—The prairie lands of the United States are very rich in humus, because the prairie grasses grew and decayed on them for centuries before they were used for farming. The soil of marshes is usually very dark-colored, because, like the leaf mold of the woods, it consists largely of humus. Whenever a farmer or gardener adds vegetable or animal matter to his soil, and permits it to decay there, he makes his soil richer in humus. The more often a soil is manured with such matter, the darker colored it is as a rule.

Humus Helps Growth of Plants.— Humus in the soil helps the growth of plants in several ways: it enables the soil to hold more water than it otherwise would; it tends

to prevent the surface of the soil from baking; it absorbs ammonia (which contains nitrogen) from the air, and thus aids in fertilizing the soil; it also serves to some extent as plant food.

Cropping Land.— When land is cropped year after year without being manured, it loses much of its humus, as well as much of its mineral plant food. Such a soil is said to be " run down " and it rarely produces good crops. It can be restored to a fertile condition only by the application of the humus and the plant food that it lacks. This may cost for a time as much as the crops from the land are worth. It is, therefore, very unwise to crop land long without restoring the humus and the plant food that are removed in the crops.

The Best Fertilizer.—The best way for the farmer or gardener to supply his land with humus is to use plenty of stable or barnyard manure. Not only does this material produce humus, but, in its early stages of decay, it absorbs some water from the air, and, as this water contains ammonia, it adds some nitrogen to the soil from the air. It also tends to warm the soil, for it gives out heat in decaying and also absorbs some heat from the air.

Plowing Crops Under.—Another way of adding humus to the soil is by plowing under unharvested crops, such as clover, rye, turnips, or buckwheat. This is often a cheaper way of supplying the soil with humus than putting on stable manure, but, except in the case of clover (Lesson 9), these crops do not add fertility to the soil, because they take as much plant food out of the soil as they return it. They are, therefore, less valuable than stable manure.

WHAT WE HAVE LEARNED.

Vegetable or animal matter in which decay is well advanced, but not complete, is called humus.

The presence of humus enables the soil to hold more water than it otherwise would, and tends to prevent the soil from baking.

Humus absorbs a little ammonia from the air, and serves to some extent as plant food, because the ammonia contains nitrogen.

"Run down" soil can be restored to fertility only by supplying the humus and plant food that it lacks.

Stable and barnyard manures are the best sources of humus in the soil. Plowing under unharvested crops also enriches the soil with humus.

9. HOW CLOVER HELPS THE FARMER.

Illustrative material: Plant not over one fourth of an inch deep in moist garden soil in a fruit jar, two or three hundred seeds of common red clover. Screw on the cap loosely, and place the jar in a warm place. When the plants are well grown, fill the jar with water and let it stand until the soil is thoroughly soaked; then gently draw the plants out so as to injure the roots as little as possible. Pass the plants about the class, and let the pupils find the swellings on the roots.

Clover a Fertilizer.— Nearly every boy and girl knows the clover plant, with its three (rarely four) oval leaflets and its pretty red or white blossoms. They know, too, that all farm animals are fond of clover, both fresh and made into hay. The intelligent farmer knows that the clover plant is valuable not only for pasture and hay, but also as a fertilizer of the soil.

Clover Takes Nitrogen from the Air.— Figure 18 shows a young clover plant. By looking closely at the picture, we may see little swellings or knobs on the larger roots. While these knobs, or *tubercles,* as they are called, are not so pretty as the leaf or the flower, they are full of interest to the educated farmer, for they serve as minute laboratories for the manufacture of nitric acid in the soil, and thus they supply the plant with nitrogen, the most important kind of plant-food.

Nitrates.—The housekeeper can not make bread out of unground wheat, however much she may have of it. The grain must first be ground and sifted, and then the fine

flour, when combined with yeast, will make good bread. About four fifths of the air consists of nitrogen, but, just as the unground wheat cannot be used for bread, so this nitrogen can not be used directly by plants as food because it is not in the right form. The nitrogen must first unite with certain substances in the soil and form what are called *nitrates* before the plant can use it for food.

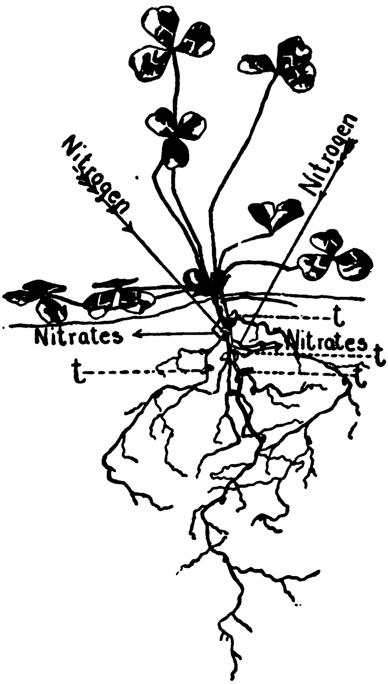


FIG. 18.—Tubercles on clover roots.

Surplus of Nitrates.— The little swellings on the clover root serve as houses in which live swarms of minute beings called *bacteria* that change the nitrogen of the air into nitrates. These not only supply the clover plant on which they live with the nitrates it needs for food, but they furnish more than the plant needs, and so make the soil more fertile. Even if the farmer mows down the clover and uses it for hay, or if his cattle eat it off, the soil will be richer in nitrates than it was before the clover was planted.

Potash Needed.— The young clover plants begin to supply nitrates to the soil when they have been growing

for a few days, and continue to do so as long as they continue to grow. Clover does not, however, enrich the soil with any kind of plant food except nitrates. If we continue to grow clover on the land and to remove the crop every year, the land is likely to become poor in potash and phosphoric acid, unless we add these to the soil. Unleached wood ashes used on clover land would supply all the food materials needed by the common farm crops.

Other Plants Similar to Clover.— Clover is not the only plant that yields nitrates from the swellings on its roots. A class of plants called legumes, such as peas, beans, vetches, lentils, and alfalfa, do the same. Crops that add nitrogen to the soil are often called nitrogen gatherers. These crops are very useful to the farmer, because they supply the soil with the most important kind of plant food, and thus, to some extent, they take the place of manure, of which farmers are almost always in need. (See, further, pages 231–236.)

Alfalfa.—Alfalfa can be grown in nearly all parts of the country. It is particularly valuable in regions not well supplied with water. The plant lives on from year to year and makes bountiful crops of hay as well as permanent pastures. Swellings or tubercles are found on the roots of this plant as well as on the clover plant, and it enriches the soil in the same way.

Cowpea.—The cowpea is neither a pea nor a bean, but resembles both plants in some ways. This plant is sometimes called the great restorer because it restores the fertility of the soil to a greater extent than any other plant. It is a legume and is especially valuable in the South, where it takes the place of clover.

Nitrogen Gatherers Make Rich Land.—The farmer should frequently grow clover, or some other nitrogen-gathering crop, on his land. Land from which a crop is harvested at midsummer, and which will not be needed until the following spring, may often better be sown to clover than left idle. As a rule, the farmers that grow and feed the most clover have the most fertile farms. The clover plant should be regarded as a symbol of good luck to the farmer, whether it has three leaves or four.

WHAT WE HAVE LEARNED.

The root of the clover plant and other legumes bear little swellings which serve as laboratories for the production of nitrates in the soil.

The legume crop enriches the soil in nitrogen, even when it is cut and removed for hay, or eaten off by cattle.

Legumes remove some phosphoric acid and potash from the soil. (See Lesson 10.)

Unleached wood ashes, applied to land, will furnish the materials removed by the legumes, and thus will maintain the fertility of the soil.

The cowpea is the greatest restorer of fertility. Other plants of the same kind are peas, beans, vetches, lentils and alfalfa. They all bear tubercles on the roots which hold large numbers of bacteria.

As a rule, the farmers that grow and feed the most legumes have the most fertile farms.

10. THE ROTATION OF CROPS.

Illustrative material: Reproduce Figures 19, 20, and 21 on the blackboard, using different colored crayons to represent the nitrogen, phosphoric acid and potash.

Plant Foods Prepared Slowly.—We learned in Lesson 8 that cropping the farm tends to make the soil "poor." Another process, however, tends to keep the soil fertile in spite of the cropping. We learned in Lesson 4 that roots can take in plant food only as it is dissolved in water. Most soils contain phosphoric acid and potash that are not yet dissolved in water, and so are not in condition to be used by plants. These undissolved food materials are slowly dissolved by the action of carbonic acid in the soil; hence the soluble phosphoric acid and potash tend to increase slowly in uncropped soils. Some ammonia also is washed down from the atmosphere by rains and snows, and this tends to increase the nitrogen in the soil. But these influences do not, in themselves, furnish enough plant food to produce a good crop every year.

Rotation of Crops.— Some products, as wheat and tobacco, remove much fertility from the soil; others, as butter, remove very little. If we raise only those products that remove much fertility, our soil will, of course, grow "poor" faster than if we grew a part of the time those that remove only a little. In the latter case, the fertility furnished by the soil and atmosphere may be

more than the amount removed, even if no manure be applied. Farmers have found it wise to make what is called a "*rotation of crops,*"— that is, to change the crop raised on a given field from year to year, rather than to raise the same crop year after year. Without rotation, certain fields on the farm would soon become too "poor" to produce good crops, while others would have more plant food than the crop needs.

Tobacco Raising Makes Land Poor.— In the pictures shown in this lesson, the amounts of nitrogen, phosphoric acid and potash removed from the soil by 1,000 pounds

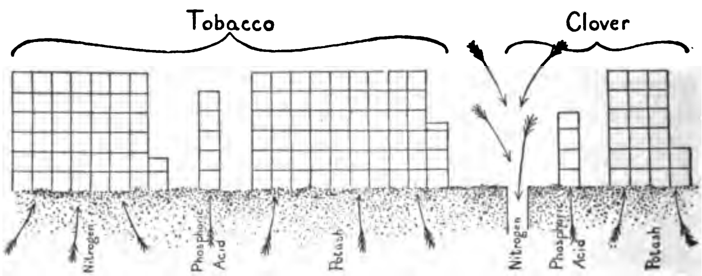


Fig. 19.— Showing the pounds of plant food removed by 1,000 pounds of Virginia leaf tobacco, and by 1,000 pounds of clover.

each of several different crops, are shown in pounds. Each small square indicates one pound. From Figure 19 we learn that tobacco removes large amounts of nitrogen and potash. More than 8,000 pounds of average barnyard manure would be required to furnish the nitrogen removed by 1,000 pounds of Virginia leaf tobacco. Tobacco is, therefore, not a profitable crop to raise unless it can be sold for a very high price.

Corn, Wheat, and Oats Require Nitrogen.— From Figure 20 we learn that Indian corn, wheat, and oats remove

nitrogen chiefly, but that they require far less of this than does an equal weight of tobacco. We observe also that Indian corn reduces the soil fertility less rapidly than oats or wheat. One thousand pounds of average barn-

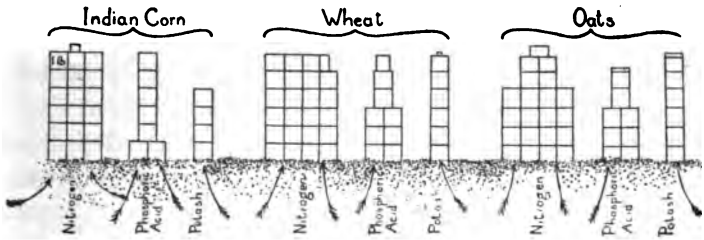


FIG. 20— Showing the amounts of the three most important plant foods removed from the soil by 1,000 pounds each of the grain of Indian corn, wheat, and oats.

yard manure contain about five pounds of nitrogen. This enables us to compute the number of tons of barnyard manure required to furnish the nitrogen for 1,000 pounds of each of the grains named.

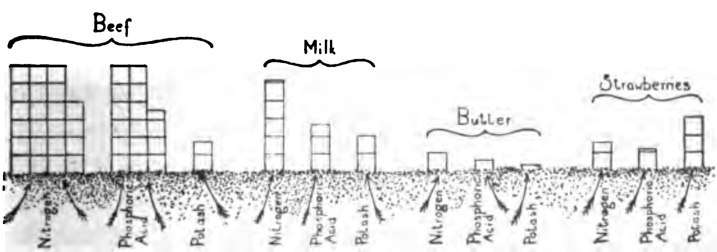


FIG. 21.— Showing the amounts of nitrogen, phosphoric acid, and potash removed from the soil when 1,000 pounds each of beef, milk, and butter are sold.

Dairying Removes Little Fertility.— From Figure 21 we learn that beef removes about as much nitrogen, pound for pound, as wheat, and more phosphoric acid. But beef is worth two or three times as much per pound as

wheat, while the amount of beef sold from the land is less than that of wheat. It is, therefore, usually more profitable for the farmer to produce beef than wheat. The plant food removed, the price in the market, and the labor required to produce a crop, must all be considered in estimating the profits in raising it. It appears from the picture that butter removes very little plant food of any kind from the soil, while it is worth from ten to twenty times as much per pound as wheat. The labor required to produce butter is, however, much greater than that required to produce wheat.

Cotton.— The cotton plant removes a large quantity of fertilizing matter from the soil, but if the lint alone were removed it would take but little from the soil. The cotton seed is very rich in nitrogen and phosphoric acid and if this is not returned to the soil the land soon becomes poor.

If the cotton seed is sold the land should be restored by growing a crop of cowpeas, alfalfa, or crimson clover.

Rotation Suggested.— These pictures, in connection with Figure 18, suggest a rotation of crops for the farmer. After raising for a time crops that remove much nitrogen, as wheat, oats, Indian corn, or tobacco, it would be wise to sow the land to clover or some other nitrogen gathering plant, and some kind of grass, and to feed the product to cattle for two or more years. The legumes will enrich the soil with nitrogen, while the small amounts of phosphoric acid and potash removed by the milk, butter, or beef, will enable the soil to become stocked with these plant foods by the natural method described in the first paragraph of this lesson.

WHAT WE HAVE LEARNED.

The action of carbonic acid in the soil slowly reduces phosphoric acid and potash to a soluble form, so that they may be used by plants.

Some nitrogen, in the form of ammonia, is washed from the atmosphere into the soil by rains and snows.

Tobacco removes very large quantities of nitrogen and potash from the soil, hence it can be profitable to the farmer only when it sells for a very high price.

The grain crops remove chiefly nitrogen from the soil. They are, therefore, expensive crops for the farmer to grow.

Beef is usually a more profitable product than wheat, not because it removes less plant food, but because it sells for much more per pound.

Milk and butter remove very little plant food from the soil.

In estimating the profits of producing a given crop, the soil fertility removed, the market price, and the labor required in production, should all be considered.

The cotton plant takes large amounts of plant food from the soil, but if the cotton seed and hulls are returned to the land there is but little loss.

Land should be frequently seeded to legumes and grass, and the product should be fed to livestock, to prevent the soil from losing fertility.

11. SAVING SOIL MOISTURE.

Illustrative material: Two lamp chimneys, a pan, fine soil and coarse soil.

Save Moisture in Soil.— We learned in Lesson 2 that water passes off the surface of the soil by evaporation, and that other water comes from below to take its place. We also learned in Lesson 3 that plants take large amounts of water from the soil, and that few field crops receive as much water as they need in summer. With the proper knowledge, the farmer and the gardener may do much to prevent the useless loss of moisture from the soil in dry weather.

Manure to Make Humus.— We learned in Lesson 8 that the presence of humus enables the soil to hold more water. A soil that contains plenty of humus catches more water when it rains than one that contains little humus. It holds the water longer in dry weather. One of the best ways to retain moisture in the soil is to use plenty of barnyard and stable manure, and thus keep the soil full of humus. Commercial fertilizers do not, to any great extent, help the soil to retain water.

Coarse and Fine Soil Compared.— In the experiment shown in Figure 22, the two lamp chimneys were filled to the dotted line with dry soil that had been sifted through a flour sieve. Enough of the soil that would not pass through the sieve was then added to the left chimney to raise the soil to the same height as that in

the other. A little water was then added to the pan. The water rose through the soil by capillary attraction at about the same rate in both chimneys until it reached the coarse soil in the left one. It continued to rise to the top of the soil in the right-hand chimney, but was held back several hours by the coarse soil at the top of the left one.

This experiment shows that, if the surface of the land is covered with an inch or two in depth of rather coarsely

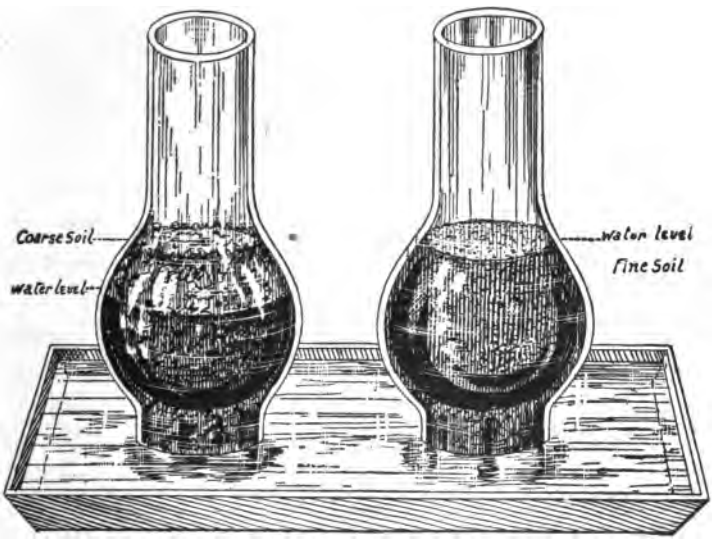


FIG. 22.— Effect of pulverizing soil.

crumbled soil, the water will rise through this layer much more slowly than through the soil below. Since evaporation occurs almost entirely at the surface of the soil, this crumbled layer greatly hinders evaporation. Plants on such land will have the water thus saved for growth. This crumbled surface is formed by passing over the

ground with a cultivator. In the garden, it may be formed with the hoe or rake. A hard rain storm compacts the soil more or less, hence the crumbling should be repeated after every such storm.

Mulching.— When the surface of the soil can not be easily cultivated, as in closely-planted orchards, evaporation may be reduced by covering with a layer of straw, leaves, shavings, tan bark or manure. This operation is called *mulching*. These materials act like crumbled soil to hinder the passage of soil water to the surface. Trees usually grow much faster on land that is cultivated or mulched than on that covered with a growing crop, because their roots are better supplied with water.

WHAT WE HAVE LEARNED.

Plowing manure into the soil helps it to catch and hold rain water.

A surface layer of crumbled soil, which may be formed with the cultivator or rake, reduces evaporation, and so saves water for the crop that is growing on the land.

A mulch of litter may be used instead of a layer of crumbled soil, to hinder the rise of water to the surface.

IRRIGATION AND DRY FARMING, see page 248.

12. THE PARASITES OF PLANTS.

Illustrative material: Portions of a plant that are being injured by an insect or a fungous disease. A blighted twig from an apple or pear tree, a scabby apple or potato, or a smutted head of grain will illustrate the latter.

The Potato Beetle.— Nearly every American boy and girl has seen the potato beetle. (Figure 23.) This is an insect that feeds on the leaves of the potato plant. The potato beetle is a *parasite* of the potato plant. There are also very small plants that sometimes grow within and between the cells of the potato plant, causing the leaves to die, and the tubers to rot. Any animal or plant, that lives in or within a larger animal or plant, feeding upon its substance, is called a parasite. The plants that live upon or within animals or other plants mostly belong to the class known as *fungi.* A single plant of this class is called a *fungus,* and parasites of this class are called *fungous parasites.* Parasites are generally harmful to the plants or animals on which they live.

FIG. 23.— Potato beetles, larva, and eggs.

Poison for the Potato Beetle.— We learned in Lesson

4 that the food for the living cells of plants is mostly formed in the leaves, and that whatever destroys the leaves cuts off a part of the food supply of the plant. Every American farmer knows that he must destroy the potato beetle or it will nearly destroy his potato crop. Since the potato beetle eats the leaves, by putting poison on the leaves we can poison the beetle. For this purpose, a deadly poison called Paris green is much used. One ounce of Paris green may be stirred into twelve gallons of water, and the mixture sprinkled on the plants. Or an ounce of Paris green may be well mixed with nine pounds of land plaster and the mixture dusted on the plants. Most other insects that eat the leaves of plants may be destroyed in the same way as the potato beetle.

Plant Lice.— Those who have the care of house plants have seen a small green insect on the under side of the leaves. This insect, commonly called the green fly or the plant louse (Figure 24), does not eat the leaves as the potato beetle does. And yet it injures the plants on which it lives. It does this by sucking out the sap, thus robbing the cells of water and food. Since it does not eat the leaves, we can not poison it by poisoning the leaves, as in the case of the potato beetle. To destroy the green fly and other sucking insects, use some substance that prevents their breathing. Strong soap suds, tobacco water, or kerosene mixed with water, sprinkled on this class of insects, usually destroys them. In greenhouses, tobacco smoke is much used for the green fly.

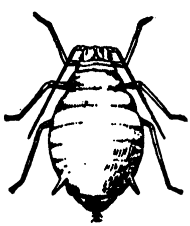


FIG. 24.—Plant louse.

Fungous Parasites.—The fungous parasites are often quite as harmful as injurious insects. The blight of the pear tree, the smutted heads of grain (Figure 25), the rotting plums and cherries on the trees and grapes on the vines, are examples of plant diseases due to injurious fungi. We have learned to prevent some of the injuries caused by fungi. It is usually important to apply our preventive before the disease appears, otherwise it may come too late to be helpful.

FIG. 25.—Heads of oats affected with smut. Reduced one-half.

Bordeaux Mixture.—To prevent harmful fungi, the so-called "Bordeaux mixture" is most used. To make this, put five gallons of water into a wooden vessel holding at least twelve gallons, and in this water hang a cloth sack containing one pound of copper sulfate (also called bluestone and blue vitriol). (Figure 26.) In another wooden vessel, slack one pound of fresh quicklime in five gallons of water. When the copper sulfate has all dissolved, and the lime has all slacked, stir up the lime and water and strain the mixture slowly through a coarse cloth into the copper sulfate solution. The coarse part that will not go through the cloth may be thrown away. The mixture is best put on the

plants with a spraying pump. (Copper sulfate is poisonous, although less so than Paris green.)

Oat Smut and Wheat Smut.—The oat smut or wheat smut attacks the plant if the seed that is planted is smutty. To prevent this, it is necessary to destroy the smut fungi on the seed before planting. The best remedy for this disease is *formaldehyde.* This is a chemical that may be purchased at the drug store. One pound of formaldehyde to fifty gallons of water will give the proper strength. Soak the grain in this chemical for about twenty minutes, and then spread it out so that it may dry without heating.

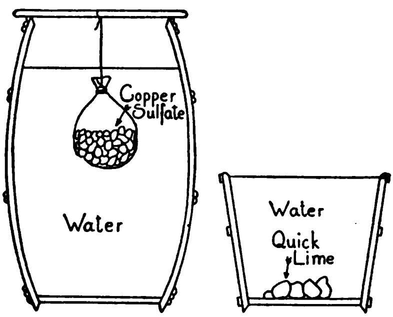


FIG. 26.— Making Bordeaux mixture.

It is probable that farmers suffer a loss of fully one-fifth of their oats and wheat through the growth of smut on the grain. This loss may be entirely prevented by the use of formaldehyde as directed. The same treatment will prevent potato scab.

Parasites are Numerous.—The harmful parasites of plants are so numerous that we can not name them all here. The methods used for destroying or preventing insects and fungi are also numerous. The farmer and the gardener may obtain books that name the leading parasites that injure each crop, and that give the best known methods of avoiding damage from them. It is necessary to keep careful watch for harmful parasites,

otherwise they may do much harm before their presence is discovered. (See also pages 237–242.)

WHAT WE HAVE LEARNED.

Plants are often injured by parasites,— that is, by animals or other plants that live on or within them.

Most insects that eat the leaves of plants may be destroyed by poisoning the leaves with Paris green mixed with water or land plaster.

Many insects that suck out the sap of plants, without eating the leaves, may be destroyed by being sprinkled with strong soap suds, tobacco water, or a mixture of kerosene and water.

Many injurious fungi may be prevented by spraying the plants on which the damage is feared with the Bordeaux mixture.

The use of formaldehyde may prevent the growth of smut on oats and wheat.

The farmer and gardener may learn from books about many harmful parasites not here named, and how to prevent damage from them.

13. SEEDS AND SOIL WATER.

Illustrative material: Put a few common navy beans into a seed tester. This consists of a layer-cake tin, two pieces of rather thick cloth, and a piece of galvanized sheet iron or tin large enough to fit loosely into the cake tin. (A common table plate, covered with a pane of glass, will take the place of the cake tin and the sheet iron cover.) The cloths should be boiled for ten minutes before they are used as this aids in keeping out mold. Wring them out until only moderately wet; place one over the bottom of the plate or tin; put the seeds on this; cover them with the other cloth; put on the cover; and set the tester in a warm place.

Place a few beans upon a small piece of damp cloth or blotting paper, cover them with an inverted tumbler and place the whole beside the seed tester.

Seeds Swollen.— If we place a few navy beans, or other thin-skinned seeds, between the moistened cloths

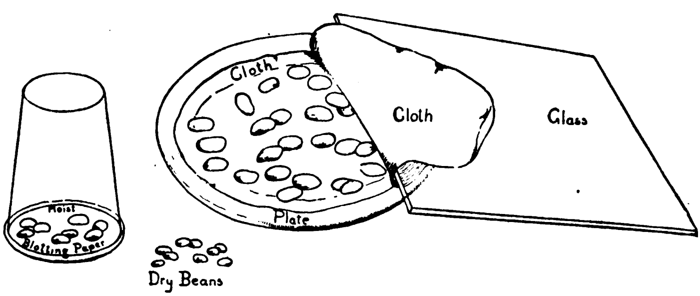


Fig. 27.— Effect of water on seeds.

of a seed tester, as shown in Figure 27, set the tester in a warm room for twenty-four hours, and then examine the seeds, we shall find them swollen to nearly twice their

former size. The seeds have swelled because they have taken in, or *absorbed*, some of the water from the cloths. When a dry sponge is soaked in water, it also swells, and so does most dry vegetable or animal material.

Seeds Surrounded with Water.— The beans under the tumbler (Figure 27), have also swelled some, but not so much as those in the seed tester. The beans in the seed tester have swelled more because they have had a wet cloth both above and below them, while those under the tumbler had the wet surface below only.

Press Soil about Seeds.— When seeds are planted in moist soil, they absorb water from the soil, just as in the seed tester they absorb water from the moist cloths. As the beans in the seed tester absorbed water faster than those under the tumbler, so seeds planted in moist soil will absorb water faster if the soil is pressed closely around them than if it is left loose. More of the particles will touch the surface of the seed, and so the water from the soil particles can enter the seed at more points at the same time. The water will also travel faster over the soil particles toward the seed, because the pressing brings the soil particles closer together.

WHAT WE HAVE LEARNED.

Most seeds absorb water freely when placed in contact with it.

The more of the surface of seeds that is in contact with the wet medium, the faster do they absorb water.

Seeds absorb water from moist soil faster when the soil is closely pressed about them than when it is left loose.

14. SEEDS CAN NOT GERMINATE WITHOUT AIR.

Illustrative material: Two shallow dishes or saucers, two tumblers, and a few grains of wheat.

Half fill two wide-mouthed bottles or two jelly cups with soil that is wet enough to be easily worked up in the hands like soft putty. Pack the soil in one of the dishes until the air is well pressed out of it, adding enough soil to make the dish half full when packed. Leave the soil loose in the other dish. Put a few wheat grains on the surface of the soil in each dish and cover these to the depth of about a quarter of an inch in the dish with the soil unpacked and with packed soil in the other dish. Close both dishes and put them in a warm place.

Air Necessary for Germination.— Figure 28 shows two shallow dishes, in each of which kernels of wheat were placed. Enough water was then added to the right-hand dish to cover the kernels to about half their depth, and to the left-hand dish to cover them to twice their depth. The dishes were then set in a warm room and covered with tumblers to prevent evaporation of the water. After two days, the kernels in the right-hand dish had germinated, while none of those in the left-hand dish had done so. Why did not the kernels in the left-hand

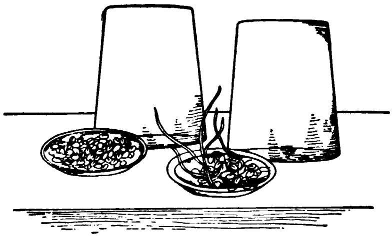


FIG. 28.— Effect of air on seeds.

dish germinate? They were in contact with water in both dishes, and both dishes were kept in a warm room. In the right-hand dish, however, the kernels were in contact with plenty of air, while in the other dish most of the air was shut out. We all know that seeds will not germinate so long as they are dry, and that, even though they have plenty of water, they will not germinate in a very cold place. But this experiment shows that, when wheat seeds have plenty of water and warmth, they will not germinate unless they also have plenty of air. The same is true of most of the seeds commonly planted on the farm or in the garden.

Some Seeds Contain Air.— The seeds of some plants that grow in water, as the water lily and rice, and of a few land plants, as Indian corn, may germinate under water. Dry seeds usually contain pores that are filled with air, and water also usually contains some air. These seeds are able to get enough air from their pores and from the water, to enable them to germinate. If they are soaked for a time in cold water to expel the air within them, and are then sealed up in a fruit jar of water from which the air has been expelled by long boiling, they can not germinate. No seeds can germinate without access to air.

Packed Soil Does Not Admit Air.— In the experiment shown in Figure 29, a few radish seeds were planted in soil that was wet enough to be easily worked up in the hands, like soft putty. The soil was then packed down closely around the seeds in one of the dishes, and left loose in the other. We now see that the radish seeds have germinated in the loose soil, while they have germinated very poorly, if at all, in the packed soil. They failed to

germinate in the packed soil because the air was largely shut out by the too wet and too closely packed soil.

Fig. 29.— Roots need air.

Wet Clayey Soil Excludes Air. — Clayey soil so wet that, with slight pressure, it becomes like soft putty, is too wet to plant seeds in. Although the seeds can absorb water rapidly from such a soil, they rarely germinate well in it, for, if it is left loose over the seeds, it dries out quickly, and, if it is packed around them, it shuts out too much air. Planted seeds should not be watered so often as to keep the spaces in the soil filled with water.

WHAT WE HAVE LEARNED.

Few seeds can germinate unless they have access to plenty of air.

Seeds of some plants can germinate under water, by using the air within them, and by absorbing air from the water. Seeds that contain no air can not germinate in water that contains no air.

Seeds should not be planted in a clayey soil that is wet enough to become, with slight pressure, like soft putty.

Planted seeds should not be so freely watered that the pores in the soil are kept filled with water.

15. PACKING THE SOIL ABOUT PLANTED SEEDS.

Illustrative material: Place an inch or more of damp garden soil in each of two pint fruit jars, and put twenty navy beans on the soil in each jar. Cover them to the depth of about two inches with the soil, packing it down firmly in one jar, and leaving it as loose as possible in the other. Screw the caps on loosely on both jars, and place them in a warm place.

Packing Loam About Seeds.— If we plant a few live navy beans in damp (not wet) garden soil in each of two jars, and then pack the soil down closely around the beans in one of the jars, leaving it as loose as possible in the other, and set both jars in a warm room for two days, we shall generally find that a larger number of the beans have germinated in the jar in which the soil was packed than in the other jar.

Absorb Water Faster.— We learned from Lesson 14 that, when we press the soil closely about seeds, the seeds absorb water and swell faster than if we leave them loose. The seeds can not germinate until they have taken up all the water they can hold. Since packing the soil about them enables them to absorb water faster, it also enables them to germinate sooner, if the soil is not too wet.

Field Illustration.— Figure 30 shows a picture of a part of a recently planted grain field. This field was sown by hand, and then harrowed to cover the seed. Wherever the man that drove the team stepped, the grain

has come up better than elsewhere, because the man's weight pressed the soil closely about the seed. Farmers and gardeners have often noticed this fact, and so they have devised various means for packing the soil over planted seeds.

Testimony of a Gardener.— Gardeners often walk with very short steps over a row of planted seeds, placing the heel of one foot against the toe of the other, so as to step on every part of the row. A very successful gardener once wrote, "As an experiment, I sowed twelve rows of sweet corn and twelve rows of beets, treading in, after sowing, every alternate row of each. In both cases, those trodden in came up in four days, while those unfirmed remained twelve days before starting, and would not then have germinated had not rain fallen."

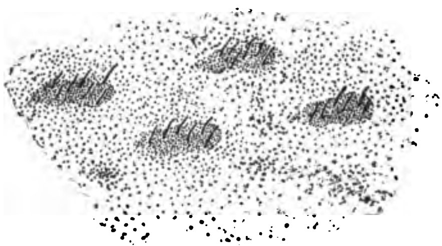


FIG. 30.— Effect of pressing the earth closely about seeds.

Rollers.— When farmers plant corn with the hand hoe, they commonly strike the soil with the flat side of the hoe, or often they step on each "hill" after covering it, to press the soil about the seed. When grain is sown in dry weather, a heavy roller is commonly driven over the land to pack the soil about the seed. Grain sowing machines, and cornplanters, often have little iron rollers attached to them to press the soil over the seed. Gardeners often use hand rollers for this purpose.

Pressing with a Board.— Very small seeds, as those of tobacco and petunia plants, are often sown on the surface of the ground without being afterward covered with soil. In such cases, the sower commonly lays over them a board on which he walks, to press the soil, and to bring the seed into very close contact with it.

Evaporation Makes Packing Necessary.— If the soil were always damp on the surface, it would not be necessary to pack it over the seed. But, since the surface tends to dry out by evaporation to the depth of an inch or two, planted seeds need to absorb their water quickly in dry weather, or the soil may become so dry about them that they can not secure enough water for germination. In this case, the seeds must wait until rain comes, or until watered, and thus the crop will be delayed or it may be entirely cut off. Thus, the simple act of pressing the soil about the planted seeds will sometimes save a valuable crop that would otherwise be lost.

Plant Soon after Plowing.— When ground is plowed in dry weather, the dry surface soil is turned under, and the more moist soil from below is brought to the top. If seeds are planted at once in this moist top soil, and the soil is well pressed about them, they will almost always germinate before the surface becomes too dry, even in time of rather severe drought. It is important in dry weather, therefore, to plant seeds as soon as possible after the ground is plowed and prepared.

WHAT WE HAVE LEARNED.

Pressing the soil about planted seeds hastens germination, and sometimes saves a crop.

The pressing is done by stepping on the planted ground, or on a board laid upon it, by pressing the ground with a hoe, or by rolling it with a roller made for the purpose.

When freshly-plowed ground is planted, and the soil is well pressed about the seeds, germination rarely fails, even in very dry weather.

16. SEED TESTING.

Illustrative material: Procure an ounce of clover seed and as many small patty pans as there are pupils. Put 100 seeds of red or white clover in the seed tester. Put in enough seeds of oats, barley, Indian corn, peas, beans, and cucumber or melon to supply each pupil with at least four of each kind.

Before taking up the lesson, remove the cover of the seed tester, and the upper cloth, and pass the open tester about the class, after which remove, with a forceps, the clover seeds that have failed to germinate, leaving all the other seeds. Count the ungerminated clover seeds, and let the pupils subtract the number from 100. Explain what is meant by the per cent of germination; i. e., the number of seeds per hundred that will germinate.

At the close of the lesson, give each pupil a thimble full of clover seed in a patty pan, and require each one to separate them into two classes, putting only clover seed in one place, and everything not clover seed in another.

Use of Seed Tester.— We learned in Lesson 13 that beans, placed between the moist cloths of a seed tester, absorb water freely from the cloths. We now learn that seeds of various kinds germinate as freely in the seed tester, as when planted in moist soil. By means of the seed tester, we can easily find out, before we plant them, whether or not a sample of seeds can germinate.

Age Affects Germination.— Not all seeds can germinate, even though they appear all right outside. Seeds germinate less freely as they become old, and, after a certain age, they lose their power to germinate. Some kinds of seeds retain their power to germinate much longer than others.

Other Causes Affecting Germination.— Seeds may fail to germinate from other causes than old age. Sometimes they are sorted when too damp, and so become musty; such seeds often fail to germinate. In the pumpkin, cucumber, and certain other plants, the seed shells are sometimes empty. Seeds of Indian corn sometimes freeze before they become dry, and so lose their vitality.

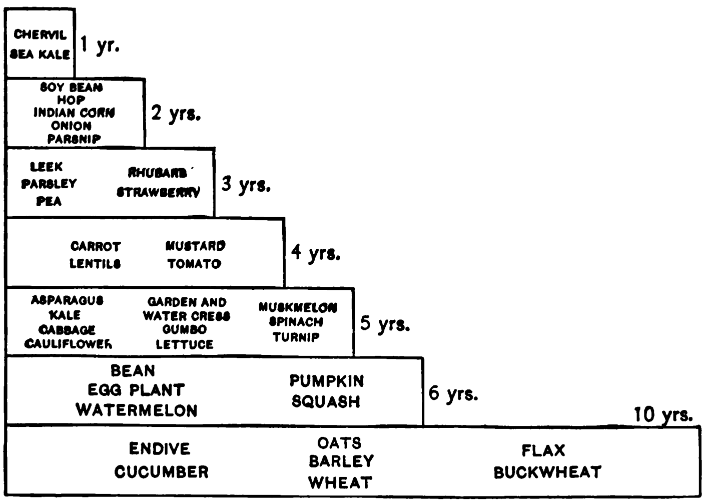


FIG. 31.— Showing the average number of years that the seeds named retain their power to germinate, under ordinary conditions.

For these reasons, it is best to test seeds before planting them, unless we know that they will germinate.

How to Make and Use a Seed Tester.— A seed tester for use at home may be made of two table plates, and two circular pieces of thick cloth large enough to cover the bottom of the plates. Put the cloths in boiling water for a few minutes before using them, to kill the spores

of fungi they may contain. Wring them out until only moderately wet, spread one over the bottom of one of the plates, and put 100 of the seeds to be tested upon it. Cover these with the other cloth, and place the second plate on the one containing the seeds, taking care that the rims are together. Set the tester in a warm room. Look at the seeds from time to time and remove all that have germinated. When all seem to have germinated that will, subtract the number that failed to germinate from 100. The remainder will show the *per cent* of live seeds the sample contains. Boil the cloths again before using them for a second test.

Importance of Testing Clover Seed Before Purchasing. — As we have learned, the clover crop is a very important one to the farmer in many countries. Most farmers need to buy their clover seed, and it is generally pretty high in price. It is important, therefore, to test clover seed before buying it. It is well to procure several different samples from the seed store, noting the price at which each can be purchased. Some of these samples will probably contain more dirt, sticks and weed seeds than others, and in some the clover seeds will germinate better than others. The best sample to buy will be the one that gives the largest quantity of *live* clover seeds for the lowest price.

WHAT WE HAVE LEARNED.

Seeds may fail to germinate from being too old, from having become musty in storage, from having been frozen before they became dry, and from being imperfectly formed.

The age at which seeds lose their vitality varies much with different kinds.

A seed tester for home use may be made of two table plates and two pieces of thick cloth.

As a rule, seeds should be tested before planting. High-priced seeds should be tested before they are bought.

17. HOW SEEDS "COME UP."

Illustrative material: Four glass jars, garden soil, and seeds of wheat, radish, pea and bean.

Planting the Seeds.— Figure 32 shows four fruit jars, each of which contains a different kind of plant. About two inches in depth of moist garden soil was put into each jar. Ten kernels of wheat were then placed on the soil in jar No. 1, ten seeds of radish in jar No. 2, ten seeds of pea in jar No. 3, and ten seeds of navy bean in jar No. 4. The seeds in all the jars were then covered about

1 2 3 4

FIG. 32.— Experiment with seeds.

an inch deep with moist soil, after which the jars were closed and set in a warm room.

Wheat and Radish Plantlets.— The seeds have now germinated, and the plantlets have just come up,— that is, they have just appeared above the surface of the soil. We may see that the plantlets are acting quite differently in the different jars. In jar No. 1, the blades of wheat

have reached the surface with very little disturbance of the soil. In jar No. 2, the radish plantlets seem to have had a harder time in coming up. Their clumsy seed leaves have lifted and moved the soil in places, and left it in slight ridges.

The Pea Plantlets.— The pea plantlets, in jar No. 3, seem to have behaved more like those of the wheat. Each appears first as a slender stem to which tiny leaves are attached, and this stem seems to have found its way among the soil particles without moving them much. There are no thick, clumsy seed leaves, as in the radish, although its stem is much thicker than that of the wheat and quite different from it in appearance.

The Bean Plantlets.— The plantlets of the bean seem to have had the hardest time of all in reaching the surface. Instead of sending up slender stems, like the peas, or thin blades, like the wheat, the now greatly swollen beans seem to have been lifted bodily out of the soil, while the earth was lifted to make way for them. The plantlets seem to have come up back foremost, with the tops pointing downward and the beans seem to have divided into halves. A little later the stems straighten up and the halves spread apart, each half becoming a very clumsy seed leaf, a little like that of the radish, but much larger.

Two Types.— The different ways in which these plantlets reached the surface illustrate two types. The wheat and pea belong to one type, in which the plantlet grows directly upward, without being hindered by clumsy seed leaves. The seeds of such plants may be rather deeply planted, and still their stems will be able to reach the surface. The radish and bean belong to the other type,

in which the greater part of what was once the seed is forced up through the soil, and appears above the surface. If the seeds of such plants are planted deeper than four or five times their thickness, the plantlets will be unable to lift the soil above them, and so can not come up at all. To this class of plants belong, besides the bean and radish, the beet, parsnip, carrot, squash, cucumber, melon, clover, buckwheat, and, in fact, almost all the common farm and garden crops, except plants of the pea family and of the grass family.

Rule for Depth of Planting.— The following rule may be safely followed for the seeds commonly planted on the farm and in the garden: Seeds of plants that come up without thick seed leaves, as Indian corn, wheat, rye, oats, barley, millet and other grasses, peas, lentils, and vetches, may be safely covered to ten times their thickness. Other seeds should not be covered more than five times their thickness. As a rule, no seeds should be covered deeper than is needful to insure a supply of soil moisture. It is often desirable to sow a crop in the orchard in summer, when the soil is rather dry; for this purpose, it is important to choose one the seed of which may be deeply planted.

WHAT WE HAVE LEARNED.

Plants may be divided into two classes with reference to the manner in which their plantlets rise through the soil.

In the pea and grass families of plants, the plantlet appears as a slender, pointed shoot that may easily work its way among the soil particles. Seeds of this class may

be planted rather deeply, and so are suitable for planting in summer when the soil is rather dry.

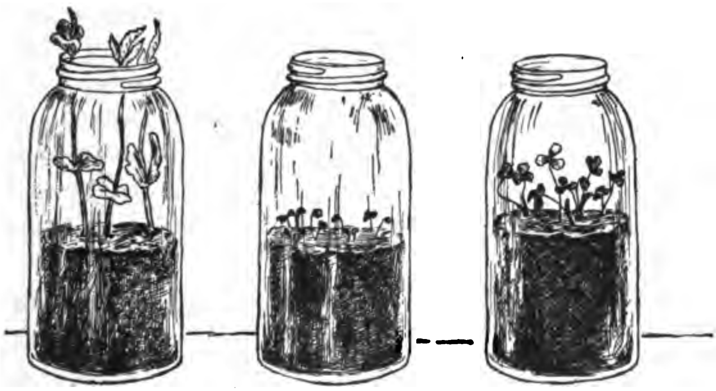
In most other farm and garden crops, the plantlet appears with two clumsy seed leaves that can not rise easily through the soil. Seeds of this class should not be planted deeper than to four or five times their thickness.

No seeds should be planted deeper than seems necessary to insure contact with enough soil moisture to enable them to germinate.

18. IT IS WISE TO PLANT THE LARGEST SEEDS.

Illustrative material: Three jars, soil, a few beans and clover seeds.

Small Seeds Not Strong.— A few navy beans were planted an inch deep in jar No. 1; a few clover seeds were planted the same depth in jar No. 2; and a few clover seeds were planted a quarter of an inch deep in jar No. 3.



1 2 3

FIG. 33.— Experiment with beans and clover seed.

As appears in Figure 33 the plantlets from the clover planted a quarter of an inch deep and from the beans have come up well, while those from the clover planted an inch deep have not.

Large Seeds are Strong.— Every perfect seed contains a plantlet, and some food to nourish the plantlet during germination. (See Figure 34.) The larger the seed is,

as a rule, the stronger is the plantlet, and the more plentiful is its food supply. This is true of different seeds of the same kind as of different kinds of seed. The bean plantlets in Figure 33 were able to come up through an inch of soil because they were well supplied with food and were strong. The clover seeds, as compared with the beans, are very small, and the clover plantlets, as compared with the bean plantlets, are very weak. The clover plantlets were unable to force their way through an inch of soil, but, as we see by looking at jar No. 3, they can grow through a quarter inch of soil. As a rule, the larger a seed is, the deeper it may be covered in planting.

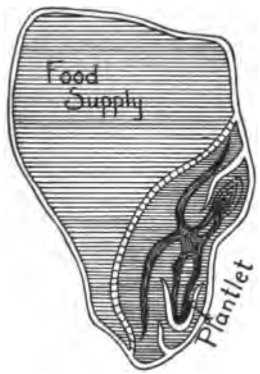


FIG. 34.— Diagram of a seed.

Planting Very Small Seeds.— As we learned from the last lesson, plantlets that bring up thick seed leaves to the surface can not grow through so much soil as those that do not. It follows that the small-seeded plants whose plantlets bring up their seed leaves must have their seeds planted in the least depth of soil of all. The clover plant belongs to this class, hence clover seed must be planted very shallow, or the plants will not come up well. The seeds of tobacco and petunia are much smaller than clover seed, and they lift their seed leaves in coming up. It is unwise to cover the seeds of these plants at all. As we learned in Lesson 15, they are commonly sown on the

surface and pressed into the soil, the surface being kept moist by frequent watering.

Profit in Planting the Largest Seeds.— Gardeners who grow radishes and lettuce under glass for the winter market find that, when they sift their seed and plant only the largest, their crops mature so much more evenly than when they sow the seeds without sifting, that the plants become fit to sell several days earlier. It is sometimes possible to grow one extra crop in the winter in this way.

Reject Poorly-formed Seeds.— Farmers pass their seed grain through a fanning mill, to take out the smallest and most shrunken kernels. Many reject the smaller kernels from the tip ends of their ears of seed corn. By growing their crops from the largest seeds, they secure a larger yield of grain than they would if they planted the seeds without sifting.

WHAT WE HAVE LEARNED.

Every perfect seed contains a plantlet and a food supply.

The larger the seed, as a rule, the more plentiful is the food supply, and the stronger is the plantlet.

The larger the seed is, as a rule, the deeper it may be covered in planting.

Very small seeds, whose plantlets bring up their seed leaves, should be covered but slightly, if at all.

Gardeners who grow radishes and lettuce for the winter market find it to their advantage to plant only the largest seeds.

It is generally possible to grow larger crops by planting the largest seeds.

19. REARING PLANTS FROM BUDS.

Illustrative material: A potato tuber, cuttings of the currant or grape vine, a cion and a small branch of the apple tree, and a bit of grafting cloth.

Roots Come from Buds.— We have now learned how to rear young plants by planting their seeds. Many kinds of plants may also be reared from buds. Some kinds are reared from buds more often than from seeds. We

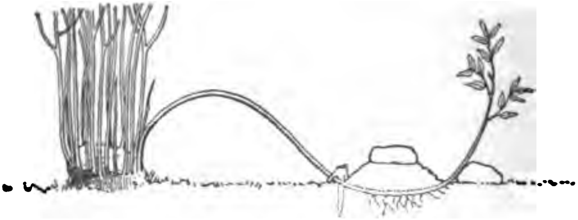


FIG. 35.— A layer.

learned in Lesson 5 that every live part of a stem terminates in a bud. In many plants, a bud, with a certain part of the stem beneath it, if kept for a time in a favorable place, will form roots of its own, and thus will become a new plant. Pieces of the roots of some plants, as the plum and cherry, if given a good chance, may also form buds on each piece, which will develop in due time into leafy stems.

Layering.— One of the simplest ways of rearing plants is by *layering*. Without being cut off, one or more branches of a plant are covered with soil. Sometimes the

branches are bent down and covered; sometimes the soil is piled up around them. (Figure 35.) Branches thus treated are called *layers*. It is better not to cover the tips of the branches. In a few weeks, roots will grow from near the buds in the covered parts of the stems. The stems can then be cut off below the roots and be planted in a new place. The currant, gooseberry, grape, quince, and many other plants, may be *propagated,*— that is, increased in number,— in this way.

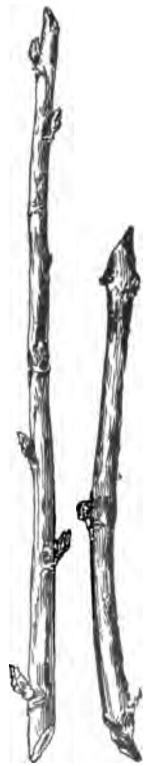


FIG. 36. — Cuttings.

Propagation by Cuttings.— A second way of rearing plants from buds is by *cuttings*. A cutting, which is a portion of a stem having at least one healthy bud, is planted in the soil. Roots may then grow from the stem, or from the base of the bud, while the bud expands into a leafy stem. Cuttings made during fall, winter, or early spring, are called *dormant cuttings*. (Figure 36.) The grape, currant, orange, and many other shrubs, are propagated from dormant cuttings. The potato is reared from cuttings of the tuber, which is a modified stem. Cuttings of woody plants may be made in the fall or spring, from wood that grew the summer before. They are commonly planted in spring in mellow soil, up to their top bud. (Figure 37.) Cuttings of some plants, especially in cold climates, are better made in the fall, then stored in moist sand or soil, and planted in the spring.

Green Cuttings.— Most plants can be reared from so-called *green cuttings*. (Figure 38.) These are made from a tender part of the stem, and each one has a leaf or a part of a leaf attached. The leaf is left on to prepare food for the growth of roots. The cuttings are commonly planted in a greenhouse bed formed of clean, rather coarse sand that is kept wet. The sand is usually kept a

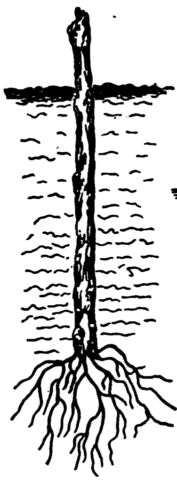


FIG. 37.— Rooted cutting.

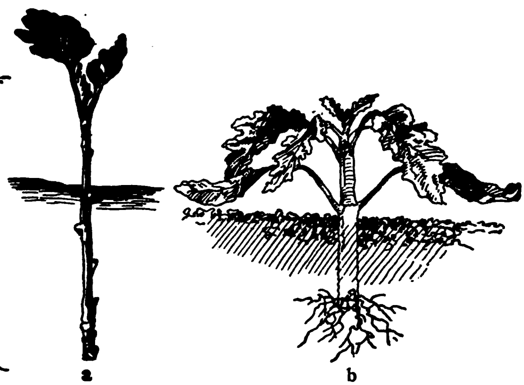


FIG. 38.— a, Cutting of chrysanthemum. b, Rooted cutting of coleus. (Both after Bailey.)

little warmer than the air above it by heating pipes below the bed. The cuttings are shaded when the sun shines. After roots form, the little plants are potted in small flower pots. Green cuttings of many plants will form roots in a saucer of coarse sand, in a sunny window, if the pores in the sand are kept filled with clean water.

Propagation by Grafting.— A third way of rearing plants from buds is by *grafting*. This is chiefly used to cause fruit trees to bear a better variety of fruit. If a

farmer has a tree that bears poor apples, and he wishes it to bear good apples, he can graft the tree over. To do this, he cuts a few young twigs from some tree that bears choice apples, and grafts them into his tree, and, if his work succeeds, his tree will bear the choice apples in about three years. The tree to be grafted over is called the *stock* and the twigs to be grafted into the stock are called *cions*.

Cutting Cions.— The cions are best cut late in fall or early in spring from firm wood that grew the summer before. Sometimes they are not cut until they are needed for grafting. If cut early, they should be kept, until warm spring weather, packed in a box with plenty of rather dry leaves, in a cool, somewhat damp, cellar. The leaves should be weighted down, to keep them close to the cions. If the main limbs of the tree to be grafted over are half an inch or more thick, it is better to use the *cleft-graft;* otherwise, the *whip-graft* is better.

FIG. 39.— Cion ready for cleft-grafting.

FIG. 40.— Cions in cleft.

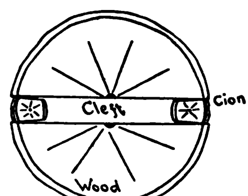


FIG. 41.— Position of cions.

Cleft - Grafting. — To make the cleft-graft, saw off about five of the main limbs that reach in different directions, at a place, if possible, where they are from one to two inches in diameter. Then place a sharp hatchet or wide chisel

flatwise across the center of the end of one of the stubs and drive it in until the stub splits open wide enough to admit a lead pencil. Next, with a sharp knife, cut two pieces shaped like Figure 39 from one of the cions, each piece having two perfect buds, pointing as shown. Insert these into the split in the stock as shown in Figure 40. Be careful to place the cions in the cleft so that the line between the bark and wood on the stock touches the like or corresponding line on the outside of the cion, as shown in Figure 41. Then cover the whole cut end of the stock, the cleft at the sides, and, also, the top end of the cions, with grafting wax. (Figure 42.) If the stub to be grafted is less than an inch in thickness, use a single cion instead of two.

Fig. 42.—Cleft-graft complete.

Whip-Grafting.— In whip-grafting, the splice is made where the stock and the cion are of about the same thickness. The cuts should be made with a sharp knife, as shown in Figure 43, *a*. They should then be slipped together, as shown

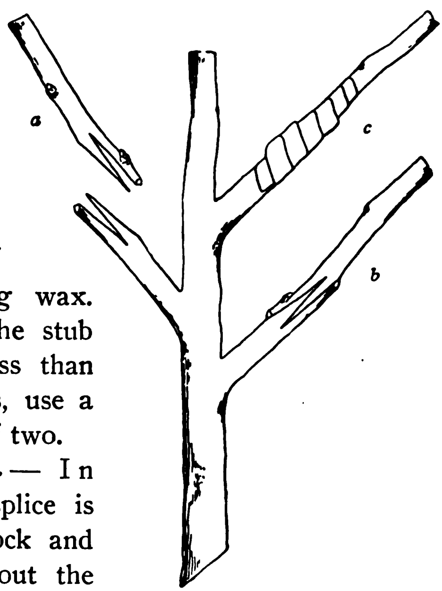


Fig. 43.—Whip-grafting.

in Fig. 43, *b*, after which the splice should be tightly wrapped with a narrow strip of grafting cloth, as shown in Figure 43, *c*.

Grafting wax is made by melting together one ounce of beef tallow, two ounces of beeswax, and four ounces of rosin. Pour the melted mass into water, grease the hands, and work it, when it is cool enough, like molasses candy, until it is the color of manilla paper. Grafting cloth is made by painting melted grafting wax on thin muslin.

WHAT WE HAVE LEARNED.

Most plants may be propagated from their buds.

Many plants may be propagated by layering,— that is, by covering their lower branches with earth. When roots are formed, the branches may be cut off and transplanted.

Certain plants may be propagated from cuttings made of dormant wood. When cuttings of such plants are planted in mellow soil, the buds will expand, and roots will grow from the stem.

Most plants may be propagated in the greenhouse from green cuttings. Green cuttings of many house plants will root in a saucer of wet sand in a sunny window.

A fruit tree may often be caused to bear better fruit by grafting. A part from the tree that bears the desired fruit is placed in close contact with a part of the tree it is desired to graft, so that the live parts of the bark in the two parts come together. The wounded surfaces are then covered with grafting wax.

20. TRANSPLANTING.

Illustrative material: A tree that has been recently dug for transplanting. Wash the roots clean and let the pupils see how many places they can find where rootlets have been broken off. If possible, give the pupils a practical demonstration lesson in tree planting out of doors.

Method of Transplanting.— It is sometimes desirable to remove a living plant, the roots of which are growing in the natural soil, to another place. This process is called *transplanting*. The more common method of transplanting is to take the roots or a part of them out of the soil, and to replant them in a new place. Sometimes a quantity of the soil that contains the roots is removed to the new place.

Rough Handling Destroys Fine Roots.— Figure 44 shows a young oat plant, the roots of which were washed out of the soil by a gentle stream of water. Most of the roots were saved. Figure 45 shows another oat plant, with which an attempt was made to draw the roots from the wet soil. Most of the roots were torn off. The latter picture shows about what happens when trees or other plants are taken up by the common methods. Only a few of the oldest and largest roots came up with the plant.

Rules for Transplanting.— We learned from Lesson 5 that the water of plants is absorbed by root hairs which grow on the youngest roots only. When a plant is taken up for transplanting, as shown in Figure 45, its power

for taking up water is mostly destroyed until some new roots are formed. Transplanting, as commonly performed, is therefore a dangerous operation for the plant. If the following rules are observed, however, the plant seldom fails to grow.

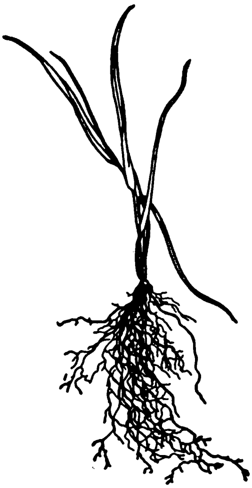


FIG. 44.— Roots of oat-plant.

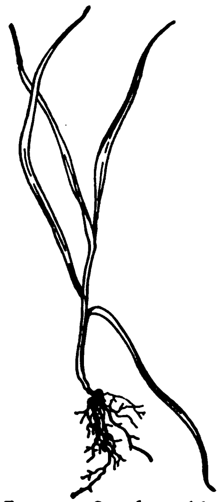


FIG. 45.— Oat plant with fine roots broken off.

(1) *Trees and shrubs that drop their leaves in autumn should be transplanted only while their leaves are off.* We learned in Lesson 3 that the water taken up by the roots is mostly transpired through the leaves. A tree or shrub without leaves needs very little water, because it transpires very little. Damage to the roots when the leaves are off is far less serious than when the plant is in full leaf. In climates having wet falls and mild winters, trees and shrubs are better transplanted in the fall; in other climates, spring is the better time.

(2) *Take up the plant with the least possible harm to the roots.* With trees and shrubs, enough earth should be removed to uncover some of the roots to their ends if possible. The younger the roots are, the more readily do they send out new roots, hence as many of the younger

FIG. 46.— Bruised root.

FIG. 47.— Cleanly cut root.

roots should be retained as possible. The roots should be kept moist while they are out of the soil.

(3) *Trim off broken and mangled roots* with a sharp knife before replanting. New roots start more freely from a smoothly cut end than from a rough and bruised one. (Figures 46 and 47.)

(4) *Cut off some of the branches before replanting.* Since some of the roots have been lost in taking the plant

up, the remaining roots will not often be able to supply so much water as is needed unless some of the branches are also removed. There is more danger of leaving on too many branches than of cutting off too many.

(5) *Make the hole large enough to receive the roots easily.* Bending the roots to make them enter the hole may cause disease. Loosen the soil in the bottom of the hole, and put in some surface soil. Replant the tree or shrub at least as deep as it grew before it was taken up.

(6) *Dip the roots in water before replanting.* This will permit the moist soil to come in the closest contact with the roots.

(7) *Pack the moist soil closely about the roots.* We learned in Lesson 15 that packing the soil about planted seeds promotes germination. For the same reason, packing the soil about the roots promotes growth.

(8) *If the soil is rather dry, add a pailful or two or water* after packing the soil about the roots and before putting in all the dirt. The amount of water will depend upon the size of the tree or shrub and the dryness of the soil. Put in the rest of the soil without treading it down. If there are sods, put them on grass side down.

(9) Some plants, as cabbage and tomato, and the evergreen tree, must be transplanted in leaf. *Such plants should generally be shaded for a time.*

(10) *Mulch the soil about the tree or shrub* if the climate is subject to drought in spring.

WHAT WE HAVE LEARNED.

Ten rules for transplanting.

21. HOW TO IMPROVE PLANTS.

Illustrative material: Show a number of individual plants of the same kind, or of branches from as many plants, and require the pupils to search out the differences shown by the same part in different specimens. Show also a number of ears of Indian corn of different forms and let each pupil pick out the best ear according to his own ideal. Always require the reasons for the choice.

Plants Not Alike.—If we go out into a field of ripe Indian corn and try to find two corn plants that are alike in all respects, we shall fail. One will be a little taller than the other; one will have a thicker stalk than the other; or one will have a longer ear than the other. If we try to pick out, from a pile of husked corn two ears that are just alike, we shall fail again. One ear will be thicker, or longer, or will have smaller kernels, than the other. We shall even find it hard to select two kernels from the same ear that are just alike. *Two plants rarely, if ever, grow just alike.*

Select Seeds with a Purpose.—Although two plants rarely grow alike, the plants that grow from the seed of a parent plant are usually more nearly like the parent than they are like any other plant. For example, if one pea plant in a row bears longer and more slender pods than any other, the plants grown from the seeds in these long and slender pods is likely to produce long and slender pods also. Some of them will probably be a little more long and slender than any of the parent pods. If we

keep on planting the peas from the longest and most slender pods, we shall by and by have a variety of which the pods will be much longer and more slender than those of common peas. Thus *we can change a variety of plant by planting year after year the seeds from only those plants that show some definite variation in a marked degree.*

Improvement by Selection.— Figure 48 shows the result that has come from saving seeds of the sugar beet

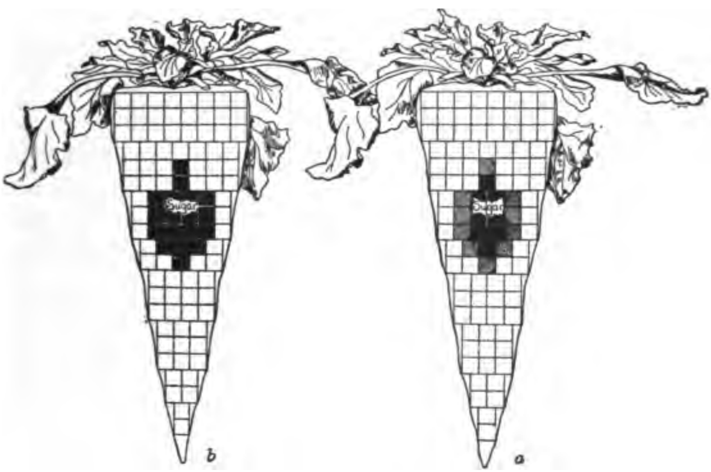


FIG. 48.— Per cent of sugar in beets.

from only those plants that had the most sugar in the juice. When the beet was first used for making sugar, the juice from the sweetest beets had only about eight per cent of sugar in it (Figure 48, *a*); but, by testing the juice of every root, and saving for seed only those of which the juice contained the most sugar, the amount of sugar has slowly been increased until now the sweetest

roots contain about eighteen per cent of sugar in their juice (Figure 48, *b*).

Consider the Plant in Selection.— We learned from Lesson 18 that it is wise to plant the largest seeds. It is also wise to select our seeds, as far as possible, from the plants that suit us best. The farmer should select his Indian corn for seed from only those plants that have the kind of ear and stalk that he would like to have in his whole field the next year. The gardener should save his tomato seeds, if at all, from only the fruits that suit him best, that grow on the plants that suit him best. *The plant should be considered, as well as the fruit.*

To Raise the Best Crops.— If the cultivator is careful to select his seeds from the best plants only, his crops will tend to improve; otherwise, they will tend to become poorer. His land not only should be well fertilized and cultivated, but should be planted to only the choicest seeds, if he would raise the finest crops. The best farmer or gardener is not satisfied with common crops. He aims to raise the best of everything, and to raise it by the best methods.

WHAT WE HAVE LEARNED.

Two plants rarely, if ever, grow just alike.

The offspring of a plant is usually more nearly like the parent than like any other plant.

We can change a variety of plant, by planting year after year the seeds from only those plants that show some definite variation in a marked degree.

The sugar content of the juice of the sugar beet has been increased from about eight per cent to about eight-

een per cent by using for seed growing only roots that were very rich in sugar.

In selecting seeds, the whole plant should be considered, and not simply the part for which the plant is grown.

One way to improve crops is to practice careful seed selection.

22. THE FLOWER AND ITS PARTS.

Illustrative material: As many flowers, of some kind that show well the calyx, corolla, stamens and pistils, as there are pupils in the class; a good pocket lens. The larger the flowers are that show these parts the better.

Necessity of Flowers.— Many flowers are among the most beautiful and delicate of natural objects. While flowers delight us by their beauty and fragrance, they serve a very important use both to man and to the plant that bears them. Without flowers, plants could not bear the fruits we prize so much for food, and the seeds. Without seeds, most kinds of plants would soon disappear, for they could form no more little plants to take the place of those that die.

Parts of the Flower.— Flowers are prettiest when left whole, but in this lesson we are to learn the names and uses of the different parts of the flower, so we shall need to pull the flowers to pieces somewhat. A flower, when complete, has four principal parts, each of which has a name and use. These principal parts are composed of smaller parts, each of which also has its name.

The Calyx and the Sepal.— Figure 49 shows a cherry blossom, cut through lengthwise. At the base, we find a green part, marked C in the figure, called the *calyx*. In some flowers, as those of the flax, the calyx is composed of several more or less leaflike parts, each of which is called a *sepal*. In the cherry flower, the sepals are

united nearly to the top. The calyx is green in most flowers, but, in the tulip and some other plants, it is of another color. The calyx forms a sort of cup that supports the rest of the flower.

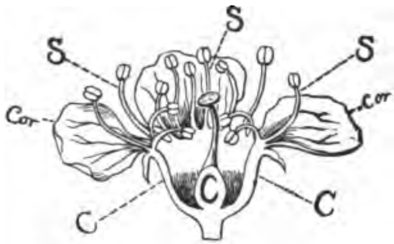


FIG. 49.— Section of cherry blossom.

The Corolla and the Petals.— The more spreading part of the cherry blossom, marked cor. in Figure 49, is the corolla. In the cherry flower, the corolla consists of five distinct parts called *petals*. In many plants, as the pumpkin and the morning glory, the petals are united. (Figure 50.) The corolla is usually of some other color than green. This helps to make the flower more easily seen, so that insects can find it.

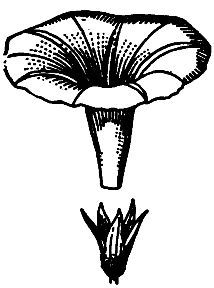


FIG. 50.— Calyx and corolla of Morning Glory.

The Stamens and their Parts.— Inside the corolla is a group of slender organs, s. s. (Figure 49), called *stamens*. Each stamen consists of three parts: the long and slender portion attached to the calyx below, called the *filament;* the swollen portion at the top, called the *anther;* and a dustlike substance found on or within the anther, called the *pollen*. The office of the stamen is to produce the pollen, without which vital seeds can not be formed. Some flowers have more stamens than the cherry blossom, while others do not have so many.

The Pistil and Its Parts.— The columnlike part in the center of the flower is called the *pistil*. This, also, consists of three principal parts. (Figure 51.) The enlarged top is called the *stigma;* the egg-shaped base is called the *ovary;* and the slender part connecting the stigma and the ovary is called the *style*. The ovary contains a smaller egg-shaped part, called the *ovule* which may later become the seed. Many flowers have more than one pistil, and many ovaries contain more than one ovule. The pistil forms and protects the ovules until they become seeds.

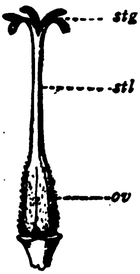


FIG. 51.—Pistil of Wild Geranium; *ov*, ovary; *stl*, style; *stg*, stigma.

Pollination.— When the pistil is mature, a drop of a sticky liquid forms on the stigma, so that a grain of pollen that happens to touch it sticks fast. If the pollen grain is from the same flower as the pistil, or from another flower of the same kind, it puts out a long tube that grows through the style into the ovary, where it comes in contact with the ovule, after which the ovule grows into a seed. (Figure 52.) The alighting of the pollen on the stigma is called *pollination*. If no pollen grain of the same kind alights on the stigma, the ovule does not become a seed, but, after a time, it perishes.

Bees and Insects Aid in Pollination.— Bees and some other insects visit flowers to get honey or pollen from them which they use as food. In entering the flowers, they become more or less dusted with the pollen, and, as they rub against the stigma, they aid much in pollination. These insects help flowers to form fruit or seeds, and so their visits to the flowers are very useful.

Pollen of Another Variety of Plant Sometimes Required for Fertilization of the Ovule.— In some of our fruits, the pollen from one flower will not form fruit or seed in the pistil of the same flower, or of another flower of the same variety. The pistil of the Bartlett pear will not often form a fruit, if it receives pollen only from Bartlett pear flowers. It must receive pollen from some other kind of pear flower than the Bartlett. So an orchard planted entirely to Bartlett trees seldom bears much fruit. In planting an orchard, it is wise, as a rule, to plant trees of several varieties together.

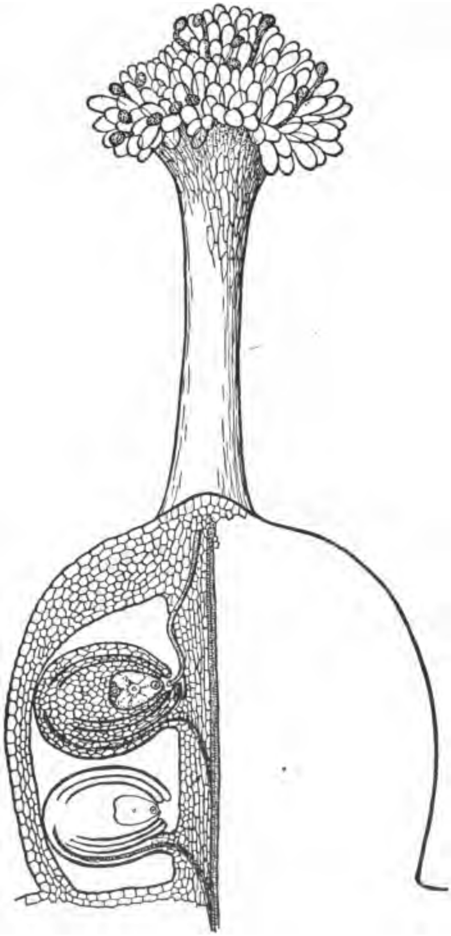


FIG. 52.— Fertilization of the ovule. The pollen tubes pass through the stigma and style, finally entering the cavity of the ovary.

WHAT WE HAVE LEARNED.

The object of the flowers is to produce seeds, that the plant may be reproduced.

The complete flower has a calyx, a corolla, stamens, and a pistil or pistils. The most important parts are the stamens and the pistils.

The stamens have at their top an anther, which is filled with a dustlike substance, called pollen.

The pistil, at its lower part, holds the ovule or ovules in the ovary.

When the pollen falls on the stigma, a growth is sent down through the pistil to the ovules, and they become seeds.

Bees and other insects often aid in pollination.

Some plants require the pollen from another plant of a different variety to make the ovules become live seeds.

23. IMPERFECT AND PERFECT FLOWERS.

Illustrative material: Some perfect and some imperfect flowers of the strawberry, squash, cucumber, melon or pumpkin; an ear of Indian corn.

Imperfect Flowers.— In Lesson 22, we learned that pollen from the anthers of a flower must find its way to the stigma before seeds can be produced. The pollen need not come from the same flower that contains the stigma. If it come from any flower of the same kind, it will answer. The flowers of some plants do not contain both stamens and pistils, but some of the flowers contain stamens only, and are called staminate; others contain pistils only, and are called pistillate. Staminate and pistillate flowers are called *imperfect.* In imperfect flowers, the pollen that reaches the stigma always comes from some other flower.

Examples of Perfect and Imperfect Varieties.— Figure 53 shows two strawberry blossoms. Notice that flower A contains stamens (S) and pistils (P). This is a *perfect* flower. Flower B, however, is imperfect — having pistils only. Strawberry flowers like B will not often produce fruit unless they receive pollen from some perfect flower like A. Some

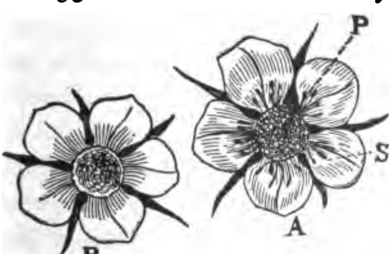


FIG. 53.— Strawberry blossoms; A, perfect; B, imperfect (pistillate).

Fig. 54.—Indian corn.

varieties of strawberry have perfect flowers, and other varieties have pistillate flowers. A variety that has pistillate flowers will not bear fruit unless plants of a variety that has perfect flowers are growing close by to furnish the pollen.

Determine before Planting the Variety of Flowers of a Plant.—By looking at the flowers of a variety of strawberry, we can tell whether it will fruit well if planted alone. If it has perfect flowers, it will; if it has imperfect flowers, it will not. Before planting a bed of strawberry plants we should find out whether the variety we desire to plant has perfect or imperfect flowers. If the plants are not in bloom, the person of whom we procure them will generally be able to tell us.

Flowers of Indian Corn are Imperfect.— The Indian corn plant has imperfect flowers. The plume-like "tassel" that grows at the top of the stalk contains many flowers, but these flowers usually contain only stamens. They yield pollen in abundance. Most country boys and girls have seen the yellow pollen dust on the leaves of Indian corn soon after the tassels form. The young ear bears the pistils, which are the so-called "silk." Each

thread of the "silk," when it receives its grain of pollen, produces a kernel on the ear. If one of the threads fails to receive its grain of pollen, a kernel on the ear will be missing. By looking closely at an ear of Indian corn, we can tell where the silk was attached to each kernel. (Fig. 54.)

Other Examples of Imperfect Flowers.— The flowers of the melon, cucumber, squash and pumpkin are imper-

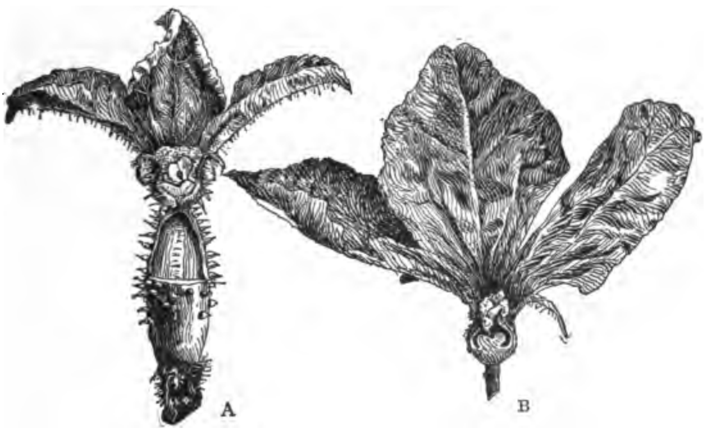


Fig. 55.— Cucumber blossoms; A, pistillate; B, staminate.

fect. By looking closely, we can easily see the two kinds of flowers. Those that bear the pollen are like B, Figure 55; while those that have the pistil are like A, Figure 55. Notice how many points of difference you can see in these two flowers. In some plants, like the maple tree and the hop plant, all the flowers on one plant bear stamens only, and all the flowers on other plants bear pistils only. The plants that bear the staminate flowers of course never produce any seed.

Cross Fertilization.— When the pollen of one flower fertilizes the ovules of another flower, the action is called *cross fertilization.* This is one of the ways of producing many varieties of plants. Cross fertilization is often brought about by the wind or by insects, and sometimes by intention of the gardener.

Plant Breeding.— By crossing certain plants with others of a similar kind, and carefully collecting the seeds that result, new and improved varieties are obtained. When an improved variety of any plant is obtained, the seeds from the plant are planted and selected so as to make a distinct breed.

Great progress has been made at the Experiment Stations in making valuable breeds of wheat, oats and corn. The yield in each case has been increased from three to ten bushels per acre.

WHAT WE HAVE LEARNED.

Imperfect flowers are those that lack either stamens or pistils.

Some varieties of strawberry are perfect and some are imperfect. Strawberries having imperfect flowers must be planted near perfect varieties.

Indian corn has imperfect flowers. The tassel furnishes the pollen, and the " silk " is a part of the pistils.

Some plants, like the maple tree and the hop, grow on one plant flowers having nothing but pistils, and on another plant flowers having nothing but stamens.

Varieties may be produced by cross fertilization, and, by careful breeding, plants may be greatly improved.

24. CROPS AND WEEDS.

Illustrative material: Samples of several of the most troublesome weeds of the vicinity. Drill the pupils until they can name them at a glance.

Weeds Not a Curse.—Weeds are plants that persist in attempting to grow where they are not wanted. It is Nature's plan to have the earth thickly covered with plants. When men began to cultivate the soil, and to decide just what kinds of plants should grow in some chosen place, they discovered weeds. Weeds should certainly, however, be kept out of our crops as far as possible. But we must not think that they were sent as a curse to man, for it is better to have the ground covered with plants, though they be weeds, than to have it bare.

Not Room for Both.— Figure 56 shows a plant of Indian corn surrounded by weeds. The roots of the corn and of the weeds are feeding from the same soil, and their stems are reaching up for the same sunlight. Surely there will not be enough water, food and sunlight for all, and so all will suffer unless some are taken out. If we hope to raise good corn, we must destroy the weeds. We learned in Lesson 11 that keeping the surface of the land covered with a layer of crumbled soil tends to prevent evaporation. Fortunately, the same treatment tends to prevent weeds from growing. The surface soil should, for this twofold reason, be kept well cultivated, especially in warm weather.

Annuals.— Some weeds grow up, blossom, ripen their seeds, and perish, all in one season. These are called *annual weeds*. Weeds of this class are usually easy to destroy, for, if we pull them up or cut them off at the surface or a little below it, they do not often grow again. Many of the most common garden weeds belong to this

Fig. 56.— Corn choked by weeds.

class. Annual weeds usually seed more freely than other kinds.

Biennials.— Weeds of another class grow in part one season and live through winter, to blossom, ripen their seed, and die, the next season. These are called *biennial weeds*. The well-known "bull thistle," so common in

old pastures, is of this class. These weeds are sometimes rather difficult to destroy the first season of their growth, for they are apt to grow up again after being cut off. If cut the second season, just before bloom, they soon die without yielding seed.

Perennials.— Weeds of a third class continue to live and bear seed from year to year, unless they are destroyed. These are called *perennial weeds.* Some weeds of this class, as the quack grass, sow thistle, and the wild morning glory, multiply from buds on underground parts as well as by seeds. Perennial weeds are the hardest of all to destroy. We learned in Lesson 4 that the food that nourishes the roots of plants is formed in the leaves. If, therefore, we prevent the leaves from growing, the roots will soon starve. This is the surest way to kill perennial weeds, although it is often hard to carry out.

Constant Warfare.— Most weeds spread chiefly from their seeds, hence care should be taken to prevent the formation of weed seeds. The more thorough we are in keeping the weeds out of our land, the easier the work becomes. While we may not hope to get rid of all weeds, we may greatly lessen their numbers by keeping up constant warfare against them.

WHAT WE HAVE LEARNED.

Weeds are plants that persist in attempting to grow where they are not wanted.

Weeds tend to rob plants of water, food and light.

Annual weeds are those that live but one season. They are easily killed by being cut off or pulled up.

Biennial weeds live two years. They are easily killed by being cut just before they would bloom.

Perennial weeds live on from year to year. Some of them multiply both from seeds and buds. They are the most difficult to destroy of all weeds. By preventing all leaf growth, we can starve the roots of all weeds.

Most weeds spread chiefly from their seeds.

25. MORE ABOUT WEEDS.

The upper part of a plant of the Canada thistle is shown in Figure 57, 1, also a portion of the underground stem with its rootlets (2). At 3, is shown a single flower, with its seed and downy hairs. The seed, also, is shown, in 4, natural size, and, in 5, as it appears under a microscope.

FIG. 57.— Canada thistle.

The root of the Canada thistle is perennial. It sends out underground stems or rootstocks in every direction. It is because of this fact that it spreads so rapidly and is so difficult to get rid of. These underground stems develop buds at their joints, which grow upward, forming new plants. Thus a single plant, if left alone for two or three years, may, by means of its rootstocks

alone, spread over a square rod or more of ground. It may spread, also, by its seeds, but this is not so likely, as most of the seeds will not germinate.

The following are the best methods for the destruction of the Canada thistle:

(1) After manuring the soil, plant it thickly with clover. When the thistles are in bloom, mow the clover, cutting down every thistle. When the clover is again up high enough to cut, plow it under carefully, harrow and roll. Keep the field well cultivated till late in the fall. Plant grain or grass the next spring.

(2) Pour oil of vitriol on the stump left in the ground after cutting off the thistle as close as possible.

(3) Apply salt liberally to each stump. Turn in sheep or goats. They will usually eat the thistles close to the ground, and prevent their growth.

(4) Seed liberally with any grass that will grow well on the ground. The thistles may be choked out by this method.

The Burdock (called, also: Great lappa, Gobo, Lappa officinalis, L. major, L. edulis, etc.), *Arctium Lappa.*—This coarse, mammoth, offensive weed, with its large brown burs that stick to the clothing and to the coats of animals, is familiar to all.

In Figure 58 is shown an illustration of a portion of the stems of two varieties of this plant in flower. At 1, is a branch of the small variety (Minor), and, at 3, one of the more common varieties (Major). At 2, a single flower is shown magnified. A shows magnified views of the seed, and B shows the seed natural size.

Though not very troublesome in cultivated ground,

the burdock pushes itself into almost every waste place where the ground is rich and where the neglect of the owner permits it to exist. Its injury to crops is far less than that of the Canada thistle, but it should not be allowed to grow, as it is most unsightly and offensive, and its clinging burs, besides being a source of annoyance to man, are often a damage to domestic animals.

FIG. 58.— Burdock.

Being a biennial plant, the burdock is not difficult to destroy. It dies, if left to itself, at the end of the second season. The important thing is to prevent its seeding, and thus keep it from spreading. During the first year of growth, the plant is easily destroyed by being pulled up by the roots when the ground is very wet. Repeated cutting a short distance below the surface of the ground may be required the second season. But, whatever method be adopted, the plant should never be permitted to bloom.

The White or Ox-Eye Daisy (called, also: Daisy, White weed, Leucanthemum vulgare), *Chrysanthemum Leucanthemum.*— It seems a pity that we are compelled

to condemn this beautiful plant as a harmful weed, but such is the case. Where it is allowed to grow, it often fills pastures and meadow lands to so great an extent as to crowd out more useful plants, and thus becomes a source of damage.

The ox-eye daisy has sometimes been cultivated in the flower garden. It is a near relative to the garden chrysanthemum. It is seldom troublesome, except in meadows or pasture lands, and grows best in rather poor soils. It is a perennial plant, and grows from an underground stem, as well as from the seed.

FIG. 59.—Ox-eye daisy; 1 stamen, magnified; 2, pistil, magnified; 3, seeds; 4, seed, magnified.

It is hardly possible to destroy the ox-eye daisy from grass land in which it has secured a hold, without breaking up the sod and summer-fallowing the ground or devoting it for a time to some hoed crop. Cutting the stems before the flowers open will prevent the seeding, but does not destroy the plant nor stop the spreading of its rootstocks.

Snap Dragon or Toadflax (called, also: Butter and

eggs, Ransted), *Linaria vulgaris.*— The snap dragon or toadflax was brought to this country as a garden flower, but it is becoming quite dangerous. It is perennial, and is spread both by its seeds and its creeping rootstocks. It tends to form a large patch, and, so far as it extends, forces out all other plants.

A plant with its head of flowers is shown in Figure 60. 1 shows a single flower; 2 shows an enlarged vertical section of the same; and 3, a matured seed pod.

FIG. 60.— Snap dragon.

For small areas, it is possible to destroy the snap dragon by grubbing out the roots, but, where the patches are numerous and large, the summer fallow is the only treatment that is likely to be successful. Young plants may be rooted out by hand at a time when the ground is very wet.

Cocklebur or Clotbur, *Xanthium strumarium.*— The cocklebur is a rapidly growing, coarse weed, with an irregularly branching stem, that grows to the height of from one to two feet. There are two kinds of flowers grown in separate heads or clusters on the same plant. The staminate flowers are produced in roundish heads at the

top of the stem. The pistillate flowers are in clusters of two or three at the base of the male stalk. These enlarge and form thick, hard, oblong burs, beset with stiff hooked prickles, and bearing two strong beaks at the upper end. These burs, like those of the burdock, stick to clothing and to the coats of animals. The upper portion of a plant of cocklebur is shown in Figure 61. At the top of the stem, the heads of staminate flowers are seen, and, at the base of the leaves, heads of the pistillate flowers. At the right, near the top of the figure, is a staminate flower enlarged. A shows a bur, and B, a section of the same, showing the two embryos. Both A and B are about natural size. Each bur, when ripe, incloses two seeds, one of which may germinate the first year, and the other lie dormant until a later time.

FIG. 61.— Cocklebur.

It has been said that the plant is poisonous to cattle, but this is probably a mistake.

The cocklebur is common in barnyards, along roadsides, in waste places, and cultivated grounds.

As the root of the cocklebur is not creeping, and does not live in the ground through winter, clean culture with some hoed crop, or seeding to clover or meadow grass, with frequent mowing, will keep it under control. It

should be carefully prevented from seeding, not only in cultivated grounds, but in waste places as well, and this is the only means by which it may be prevented from becoming troublesome. It is often necessary to go through corn and stubble fields in August or September for this purpose.

The Sow Thistle (called, also: Field sow thistle, Perennial sow thistle), *Sonchus arvensis.*— This plant is almost as bad as the Canada thistle. Indeed, some farmers who have contended with both of these enemies have pronounced the sow thistle the more unmanageable of the two.

FIG. 62.— Sow thistle in bloom.

The plant of the sow thistle is softer and less rigid than that of either the Canada thistle or the bull thistle. The leaves are thinner and smoother, and, while having prickles on their borders, are so soft and flabby that they may be easily handled. The stem, which is free from

prickles, grows from one foot to two feet in height, is hollow, and gives out a milky juice when cut. The flowers, which are produced in large heads at the top of the stem, are bright yellow. The plant is perennial, and, like the Canada thistle, grows from underground buds, as well as by seed. In Figure 62, is shown a specimen of the perennial sow thistle. Young plants of the sow thistle, as they appear on the surface of the ground in spring or autumn, are illustrated in Figure 63.

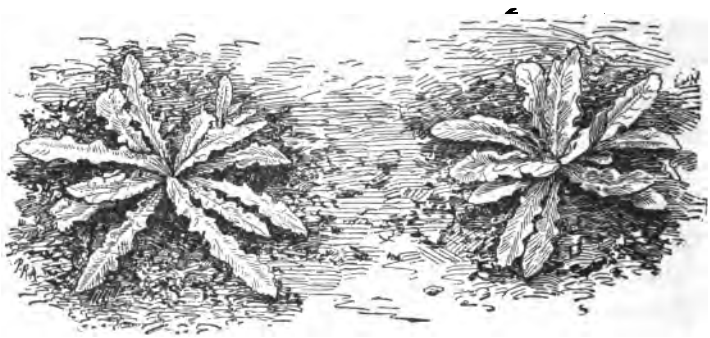


FIG. 63.— Young sow thistles.

Sour Dock (called, also: Yellow dock, Curled dock, Narrow dock, Curled rumex), *Rumex crispus*.— Like the burdock, this plant is a coarse and homely intruder into waste lands. Its roots are believed by some to be valuable for use in medicine and its young leaves make excellent greens; but the ground it occupies is far preferable to its company, and it should be persistently hunted out and destroyed.

The sour dock is a rank, coarse, deep-rooting perennial weed. The rather slender branching stem grows to three

or four feet in height, and ends in a long, somewhat plumelike, compound flower stalk of greenish leaves. These are followed by numerous angular brown seeds, shaped somewhat like kernels of buckwheat. The rather long and narrow, sharp-pointed leaves have distinct vein markings, and are strongly wavy-curled on the borders. They are borne on rather long leaf stalks, and, where each one of these clasps the stem, a branch starts out. The plant has a long, spindle-shaped, yellow taproot. A specimen is shown in Figure 64.

FIG. 64.— Yellow dock; *a*, seed, magnified.

Perhaps the best method of destroying the yellow dock is to root it out by hand at times when the soil is very wet. By clasping the stem just at the surface of the ground and giving it a slight twist and a strong quick pull at the same time, the root will usually come out almost entire. The more common method of cutting off

the stem with the scythe or hoe does not destroy the root.

Wild Mustard (called, also: Charlock, English charlock, Kerlock, Kellock, Sinapis arvensis), *Brassica Sinapistrum.*— The wild mustard is a coarse, rough, annual plant, much like the garden radish, except that it has a more irregular and branching root. The stem and branches end in clusters of yellow flowers, of which the lower ones are first to open. The stem continues to lengthen, forming a long, leafless flower stalk, with knotted buds toward the base, open flowers toward the summit, and a cluster of unopened flowers at the top. The seeds resemble those of the cabbage, and have a harsh, biting taste. A portion of a plant of the wild mustard is shown in Figure 65.

Fig. 65.— The wild mustard. An individual flower and a seed-pod appear at the left, and at the lower left-hand corner is shown a flower.

The best way to get rid of the wild mustard is to go through grain fields and other places where it grows, and pull out the plants while they are in bloom, and hence easily seen. Not one should be permitted to remain. The labor this makes necessary is not so great as one who has not tried it might think. No grain should be sown

which contains the seeds of wild mustard, when this can be helped.

The Wild Parsnip, *Pastinaca sativa*.— The wild parsnip is the wild form of the common garden parsnip, and is hence readily known. The illustration, Figure 66, is from a plant taken from a meadow, and of which the root leaves had perished.

FIG. 66.— Wild parsnip.

The plant is biennial, forming its root leaves the first season and its flower stalk the second. Perhaps the best method of destroying the young plants is by pulling them out at a time when the soil is filled with water and the roots may be drawn out nearly entire. Cutting off the young plants with the hoe tends rather to increase than to kill them. Cutting the flower stalks of the second year plants before the seeds are old enough to become ripe will prevent spreading by the seeds, and, as the parent plant has run its course, it will soon perish.

The Russian Thistle (called, also: Russian cactus, Saltwort, Tartar weed, Hector weed), *Salsola kali*, variety *tragus*.— The Russian thistle is an annual plant, coming each year from the seed. It grows from a single, small, light-colored root less than half an inch through and from six to twelve inches in length, to the height of

from six inches to three feet, branching profusely, and, when not crowded, often forms a dense, brushlike plant from two to six feet in width, and from one half to two thirds as high. When young, it is a very harmless looking plant, tender and juicy throughout, with small, narrow, downy, green leaves. When the dry weather comes in August, the tender, downy leaves wither and fall, and the plant increases rapidly in size, sending out hard,

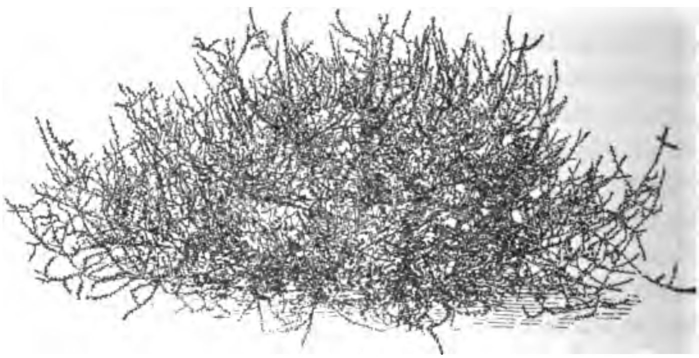


Fig. 67.— Russian thistle. The above plant was fully three feet in diameter.

stiff branches. Instead of leaves, these branches bear at intervals of half an inch or less, three sharp spines, which harden, but do not grow dull, as the plant increases in size and ugliness. The spines are from a quarter to a half inch in length. At the base of each cluster of spines, is a papery flower about one eighth of an inch in width. If this be taken out and carefully pulled to pieces, a small, pulpy, green body, coiled up and appearing like a tiny green snail shell, will be found. This is the seed. As the seed ripens, it becomes hard and of a rather dull-gray color. At the earliest frost, the plants change in

color from dark green to crimson, especially on the most exposed parts. When the ground becomes frozen and the November winds blow across the prairie, the small root is broken or loosened and pulled out. The dense, yet light, growth, and the circular or hemispherical form of the plant, fit it most perfectly to be carried by the wind. It goes rolling across the country at racing speed, scattering seeds at every bound.

FIG. 68.— Branch from Russian thistle, showing appearance of plant when seeds are mature; *a*, from a young plant, showing the appearance before the dry season; *b*, mature seed.

The best method of destroying Russian thistles is by plowing in August or September, before they have grown large and stiff, and before they have gone to seed, using care that all seeds are well turned under. If the season be long and weeds come through the furrow, it may be necessary to harrow the land before winter. Burn over the stubble fields as soon as possible after harvest. Cut the stubble with the mowing machine if the fire does not burn everything clean. Cutting the stubble and thistles

before the latter have gone to seed will help, but burning is essential to complete success, as, otherwise, the thistles will send out seed-bearing branches below the places where the mowing machine cuts them.

FIG. 69.— Branch of Russian thistle, showing appearance before flowering and before the spiny branchlets have elongated; *a*, spines; *b*, young grain with the covering removed; *c*, blossom removed from the axil and viewed from below; *d*, section of fruiting calyx, side view; *e*, same, seen from above.

Corn, potatoes, beets, or any other cultivated crop, *well taken care of*, will, in two years, rid the land, not only of Russian thistles, but, also, of nearly all other weeds.

Sheep are very fond of the Russian thistle until it becomes too coarse and woody. The young plants may, therefore, be kept down by pasturing sheep on them, and the only valuable quality these troublesome plants have may in this manner be utilized.

If the Russian thistle is to be kept out of the cultivated fields, it must be got rid of along roadsides, railroad grades, waste land where the sod has been broken, and, in fact, in all places where it may, by chance, have obtained a foothold.

Quack Grass (called, also: Couch grass, Quitch grass, Quick grass, Wheat grass, Dog grass, Tommy grass, Triticum repens), *Agropyrum repens.* — Quack grass has some excellent qualities as a fodder plant. It is said to surpass timothy in nutritive value, but, when it takes possession of the soil, nothing else can be grown. It puts out strong underground stems, which root and send up new stems at their joints. These underground stems often show their power by growing through potatoes or bits of wood that chance to lie in their path. They form a stiff sod that often severely tries the muscles of the plowman's team. Branches do not usually come from every joint, but if the stems are broken or cut in pieces, as with a plow, hoe or harrow, each piece sends up a stem and leaves from any joint it may have, and becomes a

FIG. 70.— Quack grass.

distinct plant. A large amount of nourishment is stored up in the underground stems, which makes them very nutritive and furnishes food for growth. The new plants formed by cutting up the old ones grow with great vigor, and so form many weeds in the place of one. The underground portions are eaten by stock when they can get at them. Horses and cows are fond of them; hogs root industriously for them and help to destroy them.

The illustration of quack grass shown in Figure 70 makes further description unnecessary.

The summer fallow is probably the most satisfactory method of destroying quack grass on any large scale. Turn the sod under in spring and plow again as often as any amount of grass appears above ground, until September, when rye or wheat may be sown if desired. It is best to remove fences or other obstructions to the plow, that make a harboring place for the underground stems.

Small patches may be destroyed by covering the ground deeply with straw or other litter, or by devoting the ground to some crop that requires clean culture, as cabbage, cauliflower or celery, provided the required clean culture be faithfully given. Patches of quack grass should never be cross plowed or cross cultivated in tilling the field that contains them, as this is one of the surest means of spreading the underground stems to new locations.

The Wild Carrot, *Daucus carota.*— The wild carrot is one of the most troublesome weeds in the eastern states, and is rapidly spreading westward. It thrives in nearly all soils and is spread rapidly by its many seeds. It re-

sembles the garden carrot so closely that it is easily known.

Figure 71 shows the wild carrot plant with the seed magnified at *c*, and natural size at *d*.

Fig. 71.— Wild carrot; *a*, plant in bloom; *b*, leaf; *c*, seed, magnified; *d*, seed natural size.

Mowing the plants as often as the flower-stalks appear will destroy them, and will also prevent their seeding. The first mowing often seems to increase the number of plants, but, as the root is biennial, it can not live long. Pulling the plants by hand, while the ground is wet, is one of the surest methods of destruction. Sheep aid in keeping them in subjection. The plant can not endure thorough cultivation and hence is rarely very troublesome in well tilled land.

Bindweed (called also: Morning glory (incorrectly), Field bindweed,) *Convolvulus arvensis.*— This is a twining or creeping plant with a perennial root and an annual stem.

The white, or reddish-tinted, funnel-shaped flowers

are about an inch long and open mostly in the morning, like those of the morning glory, with which this plant is often confused. The plant is a rapid grower and spreads chiefly by means of its fleshy underground stems like the Canada thistle. The wonderful power of the plant to increase is shown by Figure 72. This illustration clearly shows that the underground stems put forth strong buds from which shoots grow upward to the surface, and that some of the main underground stems extend horizontally several inches below the plow line, which fact easily explains the failure of the plow to destroy this plant.

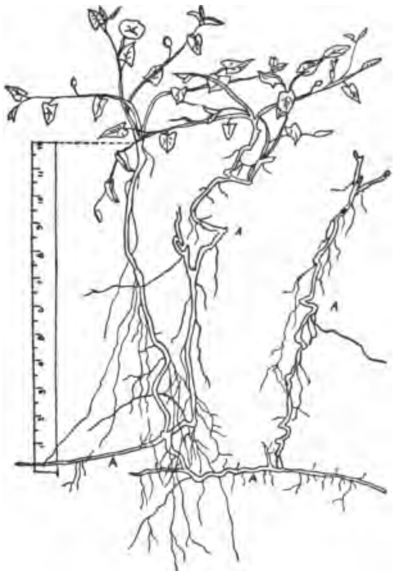


FIG. 72.— Bindweed, showing underground stems at A A. (Reduced.)

The bindweed is a most troublesome weed where it once gets a start. It does not spread rapidly when left to itself, but it is extremely difficult to destroy, and small patches of it in cultivated ground are liable to be widely scattered by the cultivating tools. Perhaps the best treatment for small patches is to cover the ground a foot or

more deep with straw, marsh hay or other litter, leaving it on until it decays.

Prickly Lettuce (called, also: Wild lettuce, Milk thistle, English thistle, Compass plant), *Lactuca Scariola*.— This plant is occupying waste grounds in many parts of the country. It is an annual, and increases only by seed, but it seeds very freely and the young plants are so strong that it spreads very rapidly where permitted to do so. It has often been mistaken for the sow thistle and sometimes for the Russian thistle.

FIG. 73.— Prickly lettuce; *a*, plant in bloom; *b*, leaf; *c*, seed, magnified.

The prickly lettuce is closely related to the common garden lettuce, which it resembles in the seed-bearing stage. The stem is smooth, with the exception of a few scattered prickles. The plant begins to bloom in July, and produces a few blossoms each morning after that time until killed by frost. An average plant has been estimated to bear more than 8,000 seeds.

Repeatedly mowing the plants as they come into bloom, or earlier, will subdue them. Thorough cultivation with a hoed crop, by means of which the seed in the soil may be made to germinate, will be found very successful. The first plowing should be shallow, so as not to bury the seeds too deep. The mature seed-bearing plants should never be plowed under, as that would plant the seeds at different depths. Mature plants should be mowed and burned before plowing. The seed appears in clover, millet, and the heavier grass seeds, and the plant is very often started by this means. As the seed may be carried a long distance by the wind, the plants must be cleared out of fence rows, waste land, and roadsides.

Long Leaved Plantain (called, also: Rib grass, Ripple grass, English plantain, Buckhorn plantain), *Plantago lanceolata.*— This plant is much like the common plantain, from which it differs in its much longer and narrower slightly hairy leaves, and its shorter and thicker seed spikes. It is perennial, and is apt to be very abundant in upland meadows, clover fields, and poorly kept lawns. It is especially to be dreaded in red-clover fields, intended to be cut for seed, since the seeds mature with those of the

Fig. 74.— Long-leaved plantain.

clover and are of so nearly the same size and weight with them that the two can not be easily separated.

The plants can be destroyed by cutting their roots off several inches below the surface of the ground and pulling off the parts cut off. They can not bear good cultivation and on rich soils they can probably be smothered out by a close June sod.

NOTE.

A large number of very common weeds have been omitted. Only those giving special difficulty to the farmer have been described. Pupils should make a study of all the weeds to be found in the neighborhood. Send to the Experiment Station in your state for a bulletin on the subject of weeds and how to destroy them, or send to Department of Agriculture, Washington, D. C., for Farmers' Bulletin No. 28.

G. & M. Ag. 9

26. THE GARDEN.

Suggestions for Work.— Every boy and girl living on a farm should have a garden. A great deal of pleasure, as well as some profit, may be obtained from planning and caring for a garden.

In the early spring, have a small plat of land set aside as your garden, to do with as you please. Send for

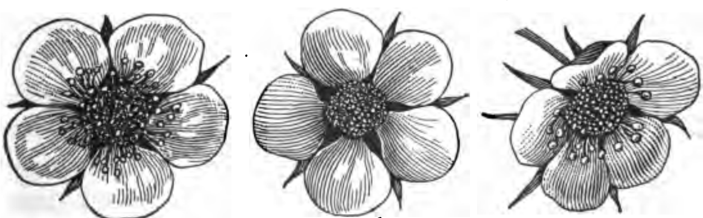
FIG. 75.—"See that the weeds are kept out."

seed catalogues, and study out just what will be best to plant in the garden. When you have done this, prepare the ground well for the seed, and, after the plants

have come up, watch their growth from day to day. See that the weeds are kept out and that the plants are cultivated as they need it. Make a success of your small farm by attention to it. It may be that you can sell something from your garden, and thus make some money for yourself. In any event, you will have the pleasure of doing something useful.

THE STRAWBERRY (Pl. I.).

The Strawberry is a good fruit for boys and girls to cultivate. The plants are easily taken care of, and may bear a full crop of fruit the next season after planting.



a *b* *c*

Fig. 76.— Strawberry blossoms.

The plants multiply during summer from trailing runners. One plant set out in spring will often form thirty or forty young plants by autumn. These will nearly all bear fruit the following summer.

There are many varieties of strawberries, and not all succeed equally well in every garden. Before deciding what variety to plant, inquiry should be made of neighbors to find what variety succeeds best in the vicinity.

Perfect and Imperfect Flowers.— There is a lesson to be learned about the flowers of the strawberry. The

flowers of some varieties are not perfect, and will not bear fruit unless a variety having perfect flowers is planted in the same plat with them. Figure 76, *b,* shows an imperfect strawberry flower, and Figure 76, *a,* a perfect one. Figure 76, *c,* has a few stamens, but is not well supplied. The little organs marked S (Fig. 53, A) are the stamens, which give out the pollen. Some of this pollen must come upon the pistils, P, or a fruit will not be produced. (Lessons 22 and 23.) If plants of a perfect-flowered variety are growing within five or six feet of those of an imperfect-flowered sort, the bees will carry the pollen to the latter plants, and they will bear fruit as well as if they had pollen of their own. Some of the most beautiful varieties of strawberries have imperfect flowers.

Care and Planting.— The best strawberries commonly grow on plants that were formed the season before, hence only these should be set. The plants are generally set out in the spring, about two feet apart, in rows three and one-half or four feet apart. A plat of plants covering five or six square rods should furnish strawberries enough for an average family. The soil should be fertile and free from perennial weeds. By autumn, the plants should have multiplied to such an extent that each row forms a bed of plants about two feet wide. Of course, all weeds should be kept out of this bed. The cultivator should be freely used between the rows to keep the soil well crumbled and to keep the plants in the different rows apart. In climates where the ground freezes much in winter, it is best to cover the strawberry bed an inch deep with clean straw or leaves just before

freezing weather. This keeps the ground from freezing and thawing often during the winter, and so tends to protect the roots from damage. In spring, the covering should be raked off and the ground between the rows well cultivated. Just before the fruit ripens, the ground between the rows should be mulched with straw or grass, to keep the fruit from being spattered with dirt by the rain.

After the strawberry harvest is past, if the bed is to be kept for another crop, it is well to mow off the plants close to the ground with a scythe or mowing machine. The cut-off material may then be dried in the sun, and, with the mulching that remains between the rows, raked from the bed and burned. This will destroy some harmful insects and diseases. The wide rows may then be narrowed down to about six inches in width. This may be done by cutting all the plants off just beneath the surface of the ground with a sharp spade, except in a strip six inches wide through the center of the row. The ground between the rows should then be enriched by spreading decayed manure over it, and should be well cultivated. If the weather be dry, the plat should, if possible, be well watered. New plants will then be formed on both sides of this narrow row, and, by fall, the rows will be as wide as they were in the spring, and most of the plants will be young.

Some gardeners plow up the strawberry bed after the first crop of berries has been picked. Others treat it as above directed, and pick a second crop the following year. Still others keep the bed until the third crop has been picked. If the bed is kept free from weeds, and is well

manured each year, the third crop may be as large as the first.

THE RASPBERRY AND BLACKBERRY.

Planting and Care.— The raspberry and blackberry are delicious fruits. The bushes generally bear prickles, and the stems die down to the base each year after fruiting. They are hardy except where winters are very cold. They multiply by suckers that grow from the roots, or by the ends of the branches taking root in the ground. The young plants are usually set about four feet apart in rows seven or eight feet apart. They begin to bear fruit the second year after planting. The ground between the plants should be cultivated or mulched. The dead stems that have borne fruit should be cut off and taken out in the fall or early spring, and the young shoots that grow from the base in spring will need thinning out after the second year. Only four or five for each plant should be allowed to grow. Where winters are very cold, the stems should be bent down and covered with earth late in autumn. To avoid breaking the stems, a little earth is removed from near their base, so that the strain of bending comes mostly on the roots.

FIG. 77.— Eldorado blackberry.

The raspberry and blackberry are not much troubled by insects.

Marketing.— The strawberry, raspberry and blackberry are largely grown for market in some localities. They generally prove profitable where the business is well managed. To be most successful, they should be grown in a location where labor and manure may be had cheap, and where they may be sent to market without having to be carried far by wagon. They are commonly sold in quart or pint boxes, which are packed in cases or crates. The picked berries should be removed promptly to a cool, shady place, and should always be handled with care to avoid bruising them. The yield of berries per acre is usually larger than that of grain.

The raspberry, in some places, is dried in large quantities, and the dried fruit brings a good price in market.

THE CURRANT AND GOOSEBERRY (Pl. I.).

Planting and Care.— The currant and gooseberry are less popular fruits than the strawberry, but they are easily grown, and at least a few bushes should be found in every garden. The bushes may be planted from four to six feet apart each way. They are very hardy and fruitful. They are multiplied by planting cuttings of the stem in moist soil, or by covering the stems with earth. As the bushes become old, the oldest stems may be cut off.

A troublesome insect, called the currant worm, generally appears on the leaves rather early in spring. If this is not destroyed, it will consume most of the leaves and the fruit will not grow well. It appears first on the lower and more central leaves of the bushes. To destroy the currant worm, sprinkle the leaves with water that has

powder of white hellebore stirred in it. This powder may be bought at drug stores. A tablespoonful should be well stirred into about three gallons of water. The mixture may be put on the bushes with a sprinkling pot.

Currants are mostly used for making jelly, for which they are much prized. There are red, white and black varieties. Gooseberries are used when green for sauce and for canning. Only the native American varieties are satisfactory in the United States.

27. THE ORCHARD.

Every farmer should have an orchard. Fruit trees of some kinds will grow wherever farm crops will grow. Good fruit not only is pleasing to the taste, but is very healthful as food.

Orchard trees are grown by planting the seeds or the pits of fruit. They need to be grafted or budded to make them bear fruit of a particular variety.

Planting.— Fruit trees rarely grow and bear fruit well unless they receive good care. They should be planted far enough apart so that the tops will not shade each other, and so that the roots will have sufficient room to procure the water they need. They should be pruned sufficiently so that the branches will not rub against each other much, and so that the sun can shine in upon the growing fruit. The ground should be manured to such an extent that the trees may have all the fertility they need for continuous fruit bearing. The soil should be cultivated during the first half of the season while the trees are growing. About midsummer, it is well to sow some quick-growing crop, as oats, peas, clover, or vetches, to furnish a cover for the ground during winter. This tends to prevent washing, deep freezing and thawing of the ground, and to save fertility.

Insect Pests.— Orchard trees need more or less protection against harmful insects and fungi. There are

various ways of giving this protection, and some special knowledge is needed for each kind of fruit. Much of this protection is given by *spraying* the trees. This means spraying them with water containing some substance that destroys the harmful insects or fungi without injuring the fruit. This is done with a force pump and hose. The hose is fitted with a nozzle that divides the stream into very fine spray.

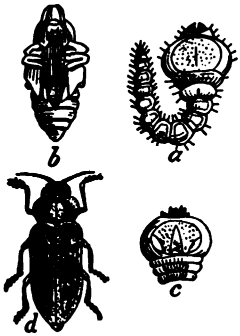


FIG. 78.— The Flat-headed borer; *a*, the larva; *b*, the pupa; *d*, the perfect beetle.

Other means of protection are necessary in some cases. Borers often injure the trunks of trees. These must be destroyed or kept out by special treatments. Insects are sometimes entrapped by placing bands about the trunks of the trees. Fruits containing insects are often destroyed or are fed to stock, to keep the insects from multiplying.

The successful fruit grower will need to study much, and to watch carefully to guard against insects and disease.

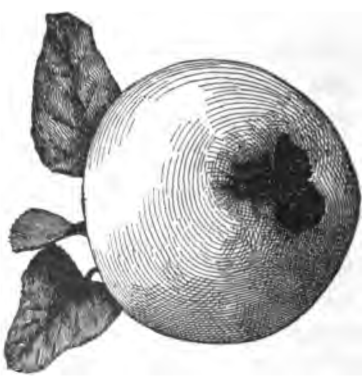


FIG. 79.— A wormy apple, showing the familiar mass of brown particles thrown out at the blossom-end by the young worm.

THE APPLE.

The Apple is the most important American fruit. It may be had in its fresh state the whole year through.

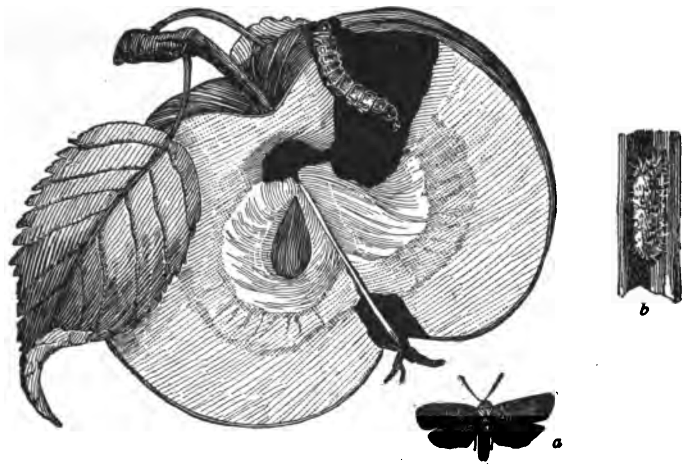


Fig. 80.— Section of wormy apple; *a*, codling moth; *b*, cocoon.

The tree is one of the largest and longest-lived of fruit trees. It begins bearing when from three to eight years of age, and sometimes lives nearly or quite a century. It is grown with more or less success throughout the United States and Southern Canada. The trees are commonly planted when about three years old, and should not be set less than twenty-five feet apart both ways. They should be pruned somewhat each year to prevent the branches from growing too thickly.

Fig. 81.— Hairy woodpecker.

The Codling Moth.— The apple is much injured by an insect called the "codling moth," of which the maggot form lives in the fruit, caus-

ing "wormy apples." It is estimated that this worm has caused over $7,000,000 damage each year in the states of Nebraska, Illinois and New York alone. The codling moth can be controlled pretty well by spraying the trees soon after the flowering period with water containing Paris green stirred in it, at the rate of one pound to two hundred gallons.

The woodpecker finds the worm hidden in his silken cocoon under the scales of the bark of the apple tree. This bird should not be killed. He is doing a good work in destroying the worms that would otherwise spoil many apples.

THE PLUM AND CHERRY.

The Plum and Cherry are favorite fruits which can be grown over much of the United States and parts of Canada. They grow on small trees that begin to bear when they are three or four years old. The trees are planted in the orchard when they are about two years old, and are set about sixteen feet apart each way.

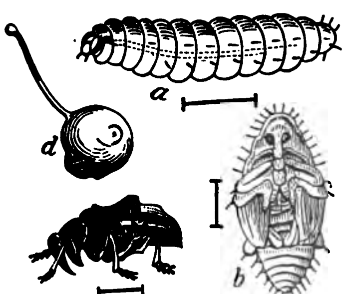


FIG. 82.—The plum tree curculio; *a*, the larva; *b*, the pupa; *c*, the beetle; *d*, curculio, on young plum. The straight lines indicate the average natural length.

The Curculio.—An insect called the curculio troubles the fruit by laying an egg in it. The egg hatches into a maggot that lives on the fruit until full grown. It is usually this maggot that causes plums to drop before they are ripe, and that causes "wormy" cherries. The

curculio may be caught by jarring it off the trees early in the morning on a sheet spread on the ground. The insect is then stiff from the cold and so does not fly.

THE PEACH.

The Peach is one of the most delicious of all fruits. It grows on a tree about as large as a plum tree. The peach tree begins to bear fruit when three or four years of age. The peach is not so hardy as the plum or cherry, and it succeeds well only in certain parts of the country; but a few trees may be planted in the orchard wherever the winter is not too cold for it, and they will often bear fruit enough for the family. The fruit of the peach is mostly borne on the shoots that grew the season before, hence it should be pruned to make plenty of young wood.

Yellows.— The peach is subject to a disease called "yellows," that has entirely destroyed many whole orchards of this tree. No remedy is known for it but to dig out and burn the affected trees.

THE GRAPE.

The Grape is a fine fruit, that is successfully grown over nearly all of the United States. Every home should have at least a few grape vines. They require little room, as they can be trained upon a fence or the wall of a building, if need be. Their fruit, which ripens in autumn, is wholesome and delicious. A plat of ground planted with grapes is called a *vineyard*. Vines in the vineyard are planted from seven to ten feet apart both ways. Grape vines bear fruit when three or four years

old. The grape is commonly multiplied from cuttings of the stem.

Pruning and Cultivating.— The grape vine is a rapid grower, and therefore needs to be severely pruned to keep it within bounds. The best fruit is borne on the shoots that grow from the part of the vine that grew the year before. In pruning the vine, we should leave on some of the wood that grew the last season, but should cut off most of the older wood. The grape vine is commonly tied to a trellis made of wire or slats. Sometimes it is permitted to climb over an arbor or summer house without much pruning, but it is only with careful pruning that the best grapes can be grown.

The ground between the rows of grapes should be well cultivated during the summer to keep down weeds.

In countries having cold winters, grape vines should be protected in winter as described in the section on the raspberry and blackberry in lesson 26.

SEMITROPICAL FRUITS, IRRIGATION, AND DRY FARMING, see page 243.

28. ANIMALS THAT DESTROY INSECTS.

Natural Destroyers.— We might greatly reduce the number of insects and worms that destroy our crops, by taking care not to destroy the animals that feed upon them. We have been so careless in destroying insects, toads, and birds that live upon the insects which do us harm, that these insects have greatly increased in number and have become pests. If all would study to preserve the friends and to destroy the enemies of our crops, we should be rid of the destructive insects in a short time.

FIG. 83.— Ichneumon fly.

Insects.[1]—The Ichneumon Fly is one of the most beautiful, as well as valuable, of insects. As will be noticed from the picture, it is boring into the trunk of a tree. It is doing no

[1] There is a popular notion that all small animals, such as flies, spiders, and the coral animals in the sea, are insects. This is a mistake, as neither the spiders nor the coral polyps belong to the insect class. The word insect is applied properly to those animals which have bodies divided into three distinct sections: the head, the thorax, and the abdomen. From the head there springs a pair of feelers called antennæ, and from the thorax six legs grow. The wasp is a good illustration of an insect. The spider has but two distinct parts, and comes under another class.

harm, however. It is seeking to deposit its eggs in the larvæ of an insect that has bored deeply into the trunk of the tree. The eggs of the ichneumon fly hatch out and live on these larvæ, causing the death of the borer. Ich-

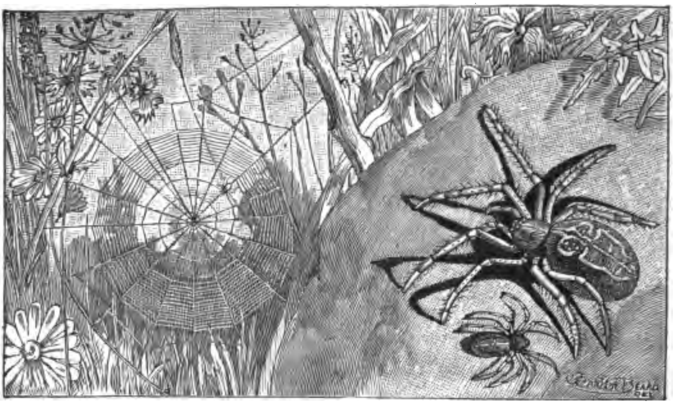


FIG. 84.— Garden spider.

neumon flies are in search of the larvæ of moths, butterflies, etc., in which to deposit their eggs. As the ichneu-

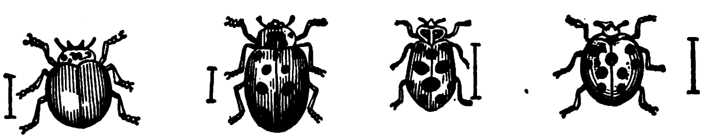


FIG. 85.— Lady-bird beetles, or "lady bugs." The straight lines represent the average natural length. These beetles are very destructive to plant lice.

mon fly hatches and becomes a fly in about fifteen days, it will destroy any larvæ in which it is deposited.[1]

[1] All insects begin life as a tiny egg. This may be laid under the bark of a tree, in the fruit, on the water, or in the dirt. After a time the egg begins to hatch. It usually produces a little worm-like creature, called a *larva*. This is sometimes called the grub or the caterpillar stage. The larva may have numerous feet and two strong jaws. It is very hungry, eats a great deal and grows rapidly. After a few days, it is fully grown, and may change into the

FIG. 86.— Dragon fly.

Lady Bugs are small beetles, with bright-colored, scaly wings. They feed on plant lice scales and the eggs and larvæ of other insects. They are among the most valuable of insect destroyers, and should be welcomed in the house and in the garden.

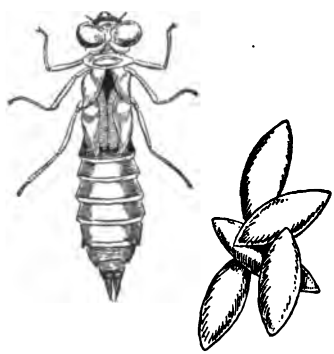


FIG. 87.— Larva and eggs of the dragon fly.

Dragon flies are beautiful insects with gauzy wings. They may be seen about ponds and streams in the summer time. They are the great enemies of the mosquitoes, the gnats, and the flies. They dart through the

pupa. **In this state, it eats nothing. If it is a butterfly or moth, it wraps itself in a silken covering or wraps a leaf about itself, and may stay in this condition for some months. At last, however, it breaks through its covering and becomes a fully developed insect. This, its last state before death, is called the *imago* state. The life history of each kind of insect varies somewhat, but almost all insects pass through the forms *egg, larva, pupa,* and *imago.***

air, and catch many small insects on the wing. When they alight, they still keep their wings outspread. They lay their eggs on the stems of water plants or on the water.

Fig. 88.— A damsel fly.

Damsel Flies are much like the dragon flies, but are smaller and fold their wings over the back when they are at rest.

Toads.— These homely looking animals are very useful in ridding us of harmful insects. If we knew all the good that they do by feeding on insects, we should not think them so ugly, and we certainly should never stone them or kill them. Insects destroy every year over $300,000,000 worth of our crops. A large part of this might be saved if we should protect the toads and increase their number. There is a popular idea that toads will make warts if they are handled. This is an error. The toad is perfectly harmless.

Bring a pair of toads into the house, and watch the good work that they do. A room may be cleared of cockroaches by leaving a toad in it over night.

Get acquainted with the habits of the toads. You will find their study very interesting. Have you seen the large masses of bead-like eggs that the female toad lays? Have you seen the tadpoles that have been hatched from the eggs? Have you watched their growth from tadpoles to toads?

If you wish to raise a colony of toads, place a pair on a stone partly out of the water in a partly filled pail or jar. After the eggs are laid, watch them as they hatch into tadpoles. The tadpoles should be fed with bits of meat or bread, until they change into toads.

FIG. 89.— Toad.

Keep the garden well stocked with toads, and very little damage from insects need be feared.

Birds.— The largest number of the birds that fly about our homes are insect destroyers. Besides delighting the eye with their beauty and filling the world full of song, they are saving the farmers millions of dollars each year. How foolish it is to shoot these valuable birds or to rob their nests!

The birds living on insects have greatly decreased in number in the past few years, and the insects have increased so greatly that the farmer and the gardener have been put to extra labor to preserve their crops.

The birds living largely on insects, worms, etc., are swallows, martins, vireos, woodpeckers, chickadees, wrens, cuckoos, swifts, and fly-catchers.

The robin and the blue bird live on about equal quantities of insects and fruit. Because they come so early in the spring and destroy so many of the insects before they have laid their eggs for the season, these birds are of great value.

Every means should be taken to attract the above mentioned birds to our homes. They should be encouraged to nest in our trees and in our barns. We should plant trees that bear berries in the fall, so that the birds may have food for the winter months, when they can find no insects. Bird houses should be built, and, when the season is dry, gourds or small pails containing water should be hung near their nesting places, and food furnished if

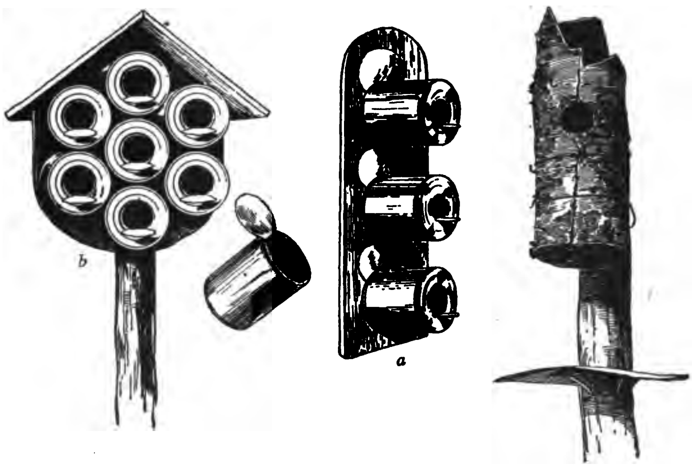


FIG. 90.— Simple bird houses.

necessary. Very comfortable nesting places may be made out of old tin cans that are thrown away. The top of the can may be bent back and nailed to a board or any flat surface (Figure 90, *a*). Then cut a small hole in the bottom of the can, allowing the tin partly cut out to project for a resting place. The cans may be grouped, as suggested in Figure 90, *b*, and held together with a hoop. Two boards may be nailed together for a roof.

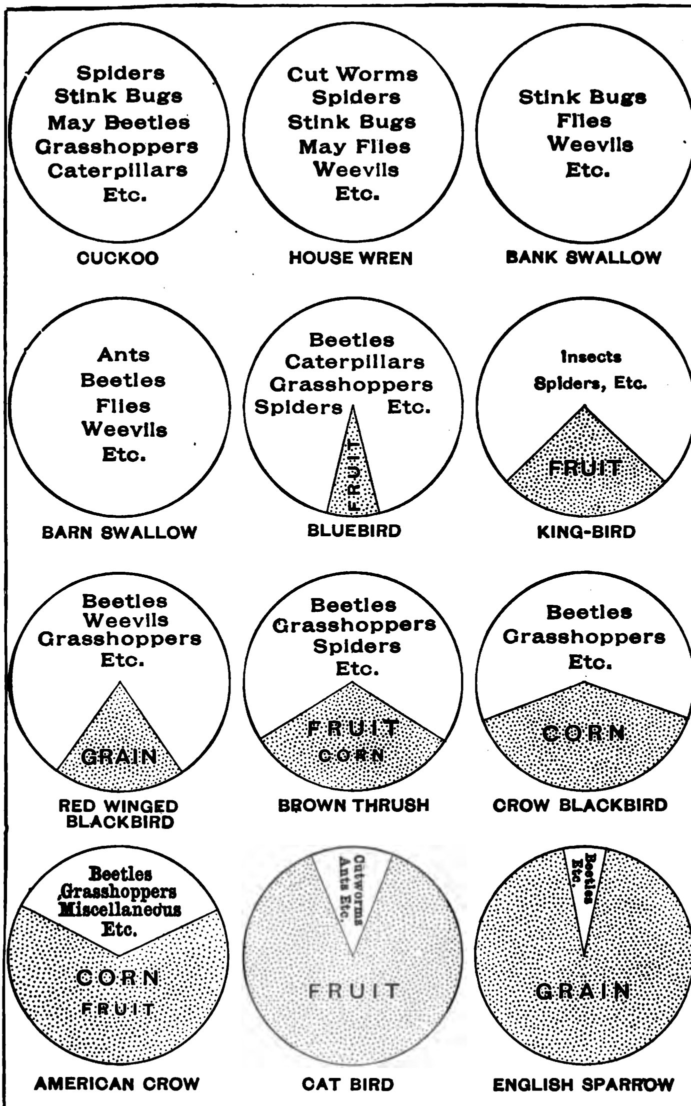


Fig. 91.— Food of some common birds.

The English sparrow is not a desirable bird for the United States. It not only eats much grain and vegetable matter, but has driven out a number of birds that are valuable as insect destroyers. We should take means to rid ourselves of this troublesome little fellow.[1]

Just after a bird has hatched, its stomach is very delicate, and it can digest animal food only. For that reason, all nestlings are fed on worms and insects. Even the birds that live mostly on grain and fruit when they

[1] The English sparrow is doing more damage to property than all the other birds in our latitude put together, and, as an agent of destruction to our native birds, the sparrow is unexcelled. No other bird will stay long where sparrows are once located. It means persecution in detail by individual sparrows and by mobs of them till all self-respecting birds are compelled to leave the locality. The English sparrow is the only bird that carries on a systematic attack upon the homes of its neighbors. It has been seen by many observers in different localities to visit the nests of its neighbors in the absence of the parent birds and to throw the young nestlings out upon the ground, in some cases dropping them ten to fifteen feet to the foot of the tree. The sparrows are with us all the year round, and, unlike most of our native birds, their food is almost entirely grain. They are, then, no substitute for the insectivorous birds that they expel, and they are a filthy nuisance about the barns and granaries as well as the dwellings where they congregate. They are a greater pest than rats and mice, and they are more difficult to combat. The most effective method of dealing with the sparrow is by poison. During the winter months, if a platform be built above the reach of the poultry, and the sparrows be fed there regularly in order to accustom them to the place, they may be easily poisoned. The recipe I quote from an article by E. B. Clark, in The Outing of January, 1901: "Mix a drachm of strychnine with three quarts of boiling water. Let the mixture boil until the poison is entirely dissolved. Into the poisoned water pour a sufficient quantity of wheat to absorb the liquid. Put the mixture aside for forty-eight hours. The wheat will be found to have swollen greatly. Spread it over the bottom of a large pan and place it in an oven until thoroughly dry. It must not, however, be allowed to scorch in the least. English sparrows consider wheat prepared in this way as a great tidbit. It gives to them a swift and painless death." This method reaches a hundred of the sparrows to ten that can be reached during any other part of the year, and farmers ought to bestir themselves, or the useful native birds will be exterminated or driven away by these sparrow pests. We must deal with the sparrows as we deal with rats and mice, and no false sentiment ought to be allowed to enter into the matter.—PROF. O. G. LIBBY.

are full grown, are very valuable in destroying insects, grubs, etc., when they are feeding their young.[1]

Examination of the stomachs of different birds (see page 149) shows what birds are of the greatest value to the farmer.

[1] During the outbreak of Rocky Mountain locusts in Nebraska in 1874–1877, Prof. Samuel Aughey saw a long-billed marsh wren carry thirty locusts to her young in an hour. At this rate, for seven hours a day, a brood would consume 210 locusts per day, and the passerine birds of the eastern half of Nebraska, allowing only twenty broods to the square mile, would destroy daily 162,771,000 of the pests. The average locust weighs about fifteen grains, and is capable each day of consuming its own weight of standing forage crops, which at $10.00 per ton would be worth $1,743.97. This case may serve as an illustration of the vast good that is done every year by the destruction of insect pests fed to nestling birds. And it should be remembered that the nesting season is also that when the destruction of injurious insects is most needed, that is, at the period of greatest agricultural activity and before the parasitic insects can be depended on to reduce the pests. The encouragement of birds to nest on the farm and the discouragement of nest robbing are therefore more than mere matters of sentiment; they return in actual cash equivalent, and have a definite bearing on the success or failure of the crops.—*Year Book of the Department of Agriculture.*

29. ANIMAL HUSBANDRY.

Importance of the Subject.— There is a large market for meats, butter, eggs, lard, etc. The demand for wool, leather, furs, feathers, glue, horns, etc., is also large. Wild animals can not supply these wants entirely. Animals must, therefore, be raised on the farm. The production of animals and of animal products, such as milk, butter, eggs and wool, is a very important branch of farming.

What Must be Learned.— Animal husbandry requires a different kind of knowledge from that required for grain, fruit or vegetable growing. Animals require more attention than field crops. Their food, drink, light, and the air that they breathe, all need to be looked after. The care of their young demands careful attention. To learn to feed animals in the way that is best for their development and also least expensive to the farmer, requires constant study.

Economy in Raising Animals.— As we have learned in previous lessons, the selling of crops from the land removes the richest part of the land. Unless this is returned to the soil in some form, the soil will become "poor," and it will be impossible to produce good crops. When animals are grown on the farm, however, the farm products grown from the soil are fed to the animals, and are largely returned to the soil in the form of manure. The animal products that are sold, as meat, butter, eggs,

etc., take away little fertility from the farm, and bring to it a comparatively large amount of money.

Breeds of Live Stock.— As there are many races of men, each having some peculiarities that distinguish it from the others, so there are great families in the animal world. These large families having distinguishing qualities that are transmitted from parent to offspring, are called *breeds*.

The different breeds of farm animals have been produced largely by careful selection and the mating of such animals as have certain traits or peculiarities that man desires to hold.

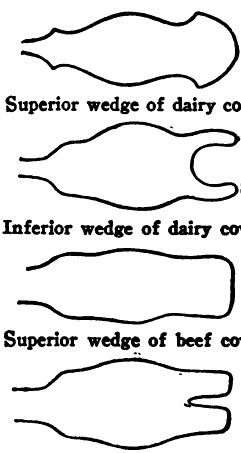
NEAT CATTLE.

The various breeds of cattle are probably descended from the same stock. Although there are about one hundred different breeds known in the world, there are but a few that are important for us to know. They may be divided into two great classes, depending on their purpose: dairy breeds and beef breeds. The dairy breeds have for their chief purpose the production of milk, butter and cheese. The beef breeds have for their chief purpose the production of flesh or beef.

30. PRINCIPAL DAIRY BREEDS (Pl. V., VI.).

The Dairy Type.— In order that the dairy cow may produce much rich milk, she must have a large stomach. Her head is usually small, but her mouth is large. The udder is wide and full, extending well forward and high up in the back between the legs. Her milk veins are large and extend well forward with many branches. In general appearance, she is loose and angular, and is not beautiful, unless the motto, "Pretty is as pretty does," be accepted. Her form presents the appearance of a double wedge.

FIG. 92.— Dairy type. (Biggle Book.)



Superior wedge of dairy cow.

Inferior wedge of dairy cow.

Superior wedge of beef cow.

Inferior wedge of beef cow.

FIG. 93.— Contrasts in "wedges." (Biggle Book.)

Jersey Cattle.— These cattle originated on the island of Jersey in the English Channel. They have been bred there for more than two hundred years, unmixed with any other breeds. A law was passed in 1779, forbidding cattle of any kind to be brought to the island for breeding. Its enforcement has kept this breed in its pure state. The cows are quite small, with deerlike heads and neat

forms. The Jersey cow is a great butter producer. The milk is very rich in butter fat, and the cream rises more rapidly and perfectly than that of most breeds. The average Jersey cows will produce 400 pounds of butter per year, and the best have produced as high as 1,000 pounds in that time.

Guernsey Cattle.— This breed was produced on the island of Guernsey, not far from the home of the Jerseys. Guernsey cattle are somewhat larger and coarser than the Jerseys, but they resemble them in their ability to produce butter. They give a somewhat larger supply of milk, and it is fully as rich as that of the Jerseys. These are very gentle cattle, and are very popular with dairymen.

Ayrshire Cattle.— These cattle are natives of the county of Ayr in the southwestern part of Scotland. They are good butter producers, but are classed chiefly as cheese cows. The quality of their milk is good and the quantity is large. The milk is easily digested even by infants, and is the best for family trade. The Ayrshires are hardy and active. They are able to gather food from scanty pastures better than other breeds. Their short, upward-turned horns, the large patches of red or brown and white, and the fine dairy form, make them a very attractive breed.

Holstein Friesian Cattle.— These cattle are sometimes called the Dutch or the Holland cattle. The breed had its origin in Holland, and is the oldest distinct breed in existence. It produces a larger quantity of milk than any other breed. The quality of the milk has not been so good as that of the other dairy breeds, but it has been much improved during the past few years.

The breed is of value also for beef. The frame is large, and the color is black and white.[1]

The Brown Swiss Cattle originated in Switzerland. They have short heavy legs, and in size and color resemble the Jerseys. They are large milk producers, and furnish some good beef.

[1] *The Dutch Belted Cattle* are much like the Holstein-Friesian, from which they are derived. They are colored black and white, the white being in the shape of a blanket or belt around the body.

31. BEEF BREEDS (Pl. VII., VIII.).

The Beef Type.— The body of the beef animal is well-rounded and compact. This arises from its tendency to lay on flesh. In general, it presents the appearance of a brick set on edge. The back is broad, both in front and behind. The udder is much smaller than in the dairy breeds. The short stout legs are set squarely at each corner of the body.

Fig. 94.— Beef type. (Biggle Book.)

Shorthorn Cattle.— This is the most important breed of cattle, and outnumbers any other breed. Its origin is in Durham County, England, and for this reason it was formerly called " Durham."

Some Shorthorn cows produce a good quantity of rich milk. Some herds are valuable as butter makers, and others for cheese production; but, as a breed, the Shorthorn belongs in the beef class, although some individuals have made great dairy records.

The Shorthorn is of a quiet disposition and is easily kept, eating coarse fodders, as well as softer foods.

The Polled Durham breed originated in America. It is very much like the Shorthorn, from which it was derived, except that it is hornless.

The Hereford Cattle.— The Herefords originated in Hereford County, in England. They are distinctly a

beef breed, the milk being of little account. The beef is good and is somewhat mixed with fat.

These animals are hardy and adapted to cold climates. The face, breast, belly, and the lower part of the legs, are white.

The Aberdeen Angus Cattle.— These are sometimes called the Polled Angus. They are black like the Galloway breed, but differ from it chiefly in being somewhat larger and finer in bone, head and hair. The hair is smooth. They are better adapted for indoor feeding.

The Galloway Cattle.— The Galloway cattle originated in Scotland. They are a polled, or hornless, breed. They have thick coats of black hair, and are especially adapted to exposure and extremes of heat and cold. They are very valuable for the western part of the United States, where they seek their own food on the plains. Their coats, when tanned, make good robes.

Devon Cattle.— Devon cattle take their name from the county of Devon, England. They are a very old breed, and were noted at first for their fine dairy qualities, but of late have been valued chiefly for their fine quality of beef.

Red Polled Cattle are very much like the Devon. They are becoming popular in this country.

The Simmenthal Cattle are of Swiss origin, and are valuable for dairy purposes, for beef, and for work.

The Native (Scrub) Cattle.— These are not a pure breed, but a mixture of breeds. There are a large number of these cattle in the United States. Although many Natives are valuable for one purpose or another, the results are very uncertain. A herd of Native cattle may be greatly improved by placing at its head a bull of the type toward which it is desired to breed.

32. DAIRYING.

Creameries and Cheese Factories.— Butter and cheese were formerly made entirely on the farm. They are now made chiefly in factories, where the milk may be had in large quantities. In this manner, the expense of manufacture is greatly reduced. A more uniform quality can also be secured, and better opportunities for selling the products are found. Some dairymen prefer to make their butter at home. With proper skill and care, excellent results are secured. The highest prices are generally received by dairymen who make their own butter, provided they use special care and skill in making it.

FIG. 95.— Old fashioned churn.

Butter factories are called "creameries." Butter made at a creamery is known in the market as "creamery butter." That made on the farm is known as "dairy butter."

The successful manufacturer of butter and cheese must have more or less special education and training. These can best be acquired in a dairy school.

MILK.

The Composition of Milk.—Milk is the most important product of the cow on the dairy farm. It is produced in the glands of the cow's udder. Milk is composed largely of water, in which fat globules are floating, and in which casein, albumen, sugar, and mineral matter or ash are dissolved. Although the amounts of these substances vary greatly, the average proportions are indicated in the diagram given (Figure 96).

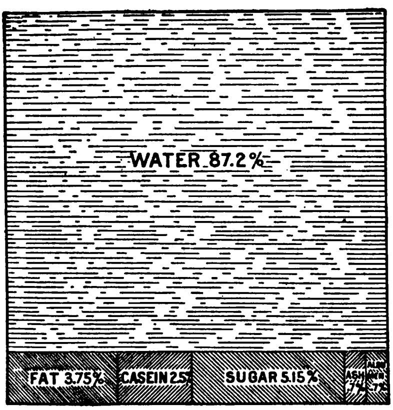


FIG. 96.— Diagram showing composition of milk. (S. M. Babcock, Wis. Bul. No. 61.)

Milk is heavier than water. Although the fat in milk is lighter than water and for that reason has a tendency to rise, the other substances in it make the milk heavier.

The Fat.— The fat in the milk is the most important element in the production of butter. It is floating in the

milk and a part of it rises to the top to form cream. Some of the fat globules do not rise to the top. They are held down by the albumen and sugar in the milk.

The fat globules vary in size. Milk from the Jerseys and Guernseys has larger globules, than that from the Ayrshires and the Holsteins. Large globules are an advantage in butter making, as they rise more easily than the small ones. Small globules are an advantage in cheese

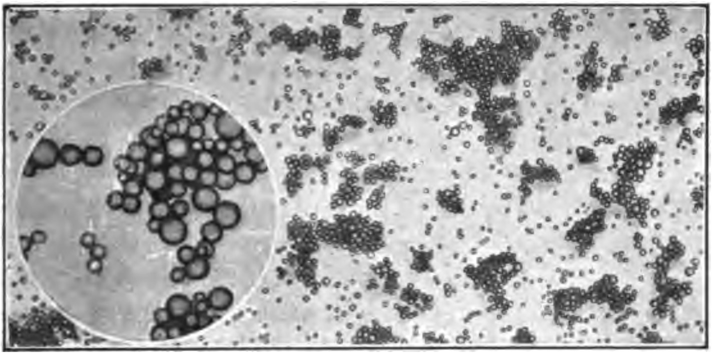


FIG. 97.— Appearance of milk under the microscope, showing the natural grouping of the fat globules. In the circle a single group is highly magnified. (S. M. Babcock, Wis. Bul. No. 61.)

making, as they do not rise so quickly, and are held in the milk when it curdles.

The fat globules are collected in irregular groups in milk. Under the microscope, these groups or families may be readily seen.

The Sugar.— The sugar in milk is not so sweet as ordinary sugar. It is called *lactose* or "sugar of milk." It is prepared for the market in some factories. It is used to make pills and powders for holding medicines.

When milk sours, the sugar is changed into *lactic acid*, which gives to milk its sour taste.

Other Substances in Milk.— *Casein* is the chief *proteid* in milk. It is of value in cheese making. If rennet or a weak acid be added to milk, the casein is changed into a curd, from which the cheese is made.

Albumen or Protein in the milk is much like albumin in the blood. It differs from casein in that it coagulates, or thickens, when heated. It is the skinlike or paperlike substance that appears on the surface of skim milk when it is boiled.

The *ash* in milk is composed mostly of *phosphate of lime*, but there are many other minerals found in small quantities.

Colostrum.— The first milk that the cow gives after the birth of a calf is called *colostrum*. It contains from ten to fifteen times as much albumen as the milk does later, and contains less fat and sugar. Colostrum is sometimes called "calves' milk." It should not be used for at least three days after the birth of the calf. It is safer to wait one week before using the milk.

Yield: Quantity and Quality.— The average cow produces about 4,000 pounds of milk per year. Some herds will yield an average of 6,000 pounds for each cow. In one exceptional case, the yield for a single cow reached 30,000 pounds. In general, the cow should yield at least six times her live weight to be a profitable member of a dairy herd.

The profitableness of a dairy cow depends as much on the quality of the milk as it does on the quantity. Milk rich in fat and of large quantity should be the aim of all

dairymen. It costs no more to raise a cow that yields fat sufficient to make 300 pounds of butter than it does to raise one producing but 200 pounds. Cows that are not profitable are called "boarders." The worst of it is that they never pay for their board.

It is well to choose a breed that will produce the desired quantity and quality of milk, but that will not be enough. Even in the best dairy breeds, there are some boarders eating up the farmer's profits. These should be got rid of as soon as discovered.

The Babcock Test.— The only certain way to find out which cows in a herd are profitable and which are not, is to make frequent tests. The milk should be weighed, and the amount of butter fat determined by the use of the "Babcock Test." This test was discovered, and the machine for making the test invented, by Dr. S. M. Babcock, of Madison, Wisconsin. The use of this simple test has been the means of improving dairymen's herds and methods everywhere. Till this discovery was made, it was difficult to tell where profits or losses were made. Now we have a sure and simple test that every farmer may use.

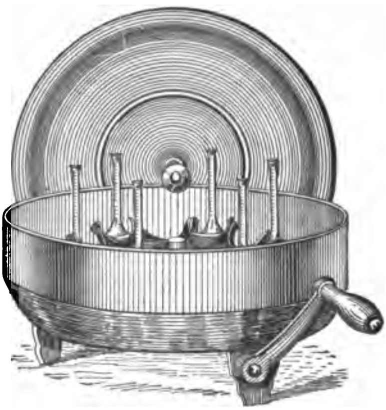


Fig. 98.— Babcock milk tester.

Full directions for operating the Babcock Test are given in the Appendix.

The Importance of Rich Milk in Cheese Making.— Even in cheese making, the richness of milk is important. The amount of casein in milk increases with the amount of fat. Besides this, the fat in the milk makes the cheese much richer and better than it would be without it.

FIG. 99.— Each cheese was made from 200 pounds of milk.

A test made in the Dairy School of the University of Wisconsin shows that milk rich in fat makes the largest and best cheese. Figure 99 shows the result of the test plainly.

HOW TO GET GOOD MILK.

Health of the Cow.— Good milk can be obtained only from healthy cows. If cows have disease of any kind, it is liable to affect the milk.

The most common of the diseases that affect cows is *tuberculosis* or consumption. It has been found that the

tuberculin test will show what cows have the disease. Such cows should be disposed of. Although cows may be afflicted with tuberculosis without spreading the disease among those who use the milk, it is not safe to use it.

To keep cows in a healthy condition, they should have plenty of pure air, good light, and clean stables. The stables should be ventilated, and should not be overcrowded. Not less than one thousand cubic feet of space should be allowed for each cow.

The stable should be kept just as clean as possible. All dirt, dust and manure should be cleaned out regularly.

Condition of the Cow.— The cow is a sensitive and affectionate animal. The yield and quality of the milk she gives depend much upon her mental condition. She becomes acquainted with her milker. If he treats her kindly she enjoys being milked, and yields her largest amount of milk of the highest quality; but if she is afraid of her milker, and if she is scolded and abused, both the quantity and the quality of her milk are reduced. These facts have been proved by the most careful experiments. The wise dairyman will make his cows comfortable by giving them food and drink that they enjoy. He will give them light and clean quarters. He will protect them from cold in winter, and from insects in summer. He will also treat them tenderly, so as to win their affection.

Condition of Surroundings.— If the cow produces good milk, the milk may still be spoiled unless all impurities are kept out of it. The milker should have clean clothes and clean hands, and should milk into pails that have been thoroughly washed. The cow should be curried and brushed, so that dirt may not fall into the pail while milk-

ing is in progress. The udder should be thoroughly clean, and the milking should be done with dry hands. The milk coming from a healthy cow is pure, but, if it is kept in a dirty stable or in a milk room where the air is not pure, it soon absorbs the foul odors and becomes tainted.

Bacteria.— There are many bacteria that get into the warm milk, and multiply so rapidly that the milk sours. To avoid the bacteria, the utmost cleanliness must be ob-

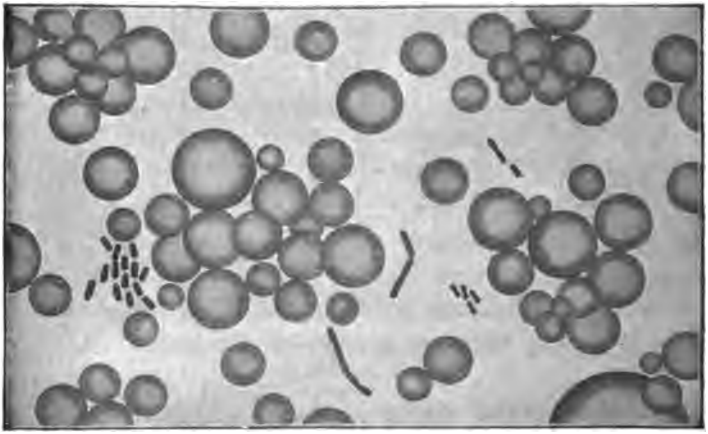


Fig. 100.— Microscopic appearance of ordinary milk showing fat globules and bacteria in the milk serum. The cluster of bacteria on left side are lactic-acid-forming germs. (H. L. Russell, Wis. Bul. No. 62.)

served in the stables, in milking and in the milk room. It will be impossible even then to avoid them altogether, but their number will be greatly reduced. Cooling the milk as soon as possible after it is drawn prevents the bacteria from multiplying, and makes it possible to keep the milk sweet.

Kinds of Bacteria.— There are many bacteria found in milk. Some work on the milk sugar, and turn it to lactic acid and thus sour the milk. Others attack the fat in milk and make butter rancid or strong. Still others give to butter its flavor. These are called *friendly bacteria,* and are often put into cream to give the butter just the flavor desired. By cleanliness and care in cooling the milk, the harmful bacteria may be held in check, so that the friendly bacteria may have a chance to grow.

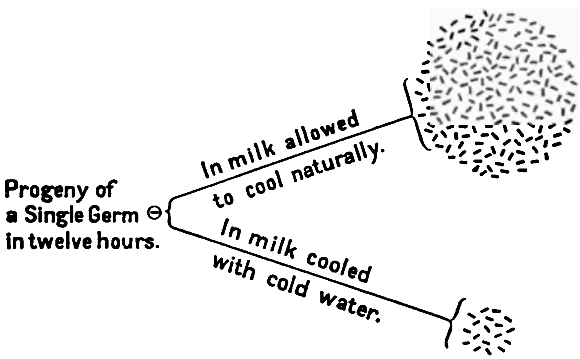


Fig. 101.— Cooling hinders growth of bacteria. (H. L. Russell, Wis. Bul. No. 62.)

Pasteurization.—It has been found possible to destroy all disease germs and the bacteria that are unfriendly in milk, by *pasteurizing* it. In this process, the milk is heated to a temperature of about 160° F., and held at that point for about fifteen minutes; then it is cooled as rapidly as possible to a temperature of 50° F. This destroys the germs but does not otherwise affect the milk. Many machines have been invented for doing this work, but it may be done in the home without the use of machinery.

The Cream Separator.—The cream separator is a machine for separating the cream from the milk. It does the work much better and much more quickly than it can be done by allowing the cream to rise in pans or in cans.

FIG. 102.—Cream separator.

The milk is turned into a bowl which is rotated rapidly. The milk being heavier than the cream, is thrown by the revolving bowl to the outside, and passes out through a spout, while the cream seeks the center and passes out through another spout. The separator collects many impurities from the milk that even the best strainers fail to catch. Separator cream is therefore much purer than other cream.

33. PRINCIPLES OF FEEDING.

Substances in Bodies of Animals.— The bodies of animals contain flesh, fat, bones, teeth, hair, etc.; or, we may say that their bodies are composed of water, ash (mineral matter), protein and fat. These are the substances that must be supplied in the food that the animals eat. The body is more than *half* water, and it is fortunate that animals have but little difficulty in getting it. Besides the water that they drink, a large part of their food is composed of water. The *ash,* or mineral matter, is found in all of the foods that animals eat. The largest part of it is phosphate of lime. *Protein* is the name given to the most important group of substances to be supplied by the food. It forms the principal part of the flesh, skin, brain and nerves. It contains nitrogen as its most important element. *Fat* is found in nearly all parts of the body, and is very important in the composition of milk.

Substances to be Studied.— Little attention need be given to supplying water or ash to animals. These may be obtained ordinarily in large quantities without cost. The protein and the fat-forming foods, however, require considerable attention. They are the expensive part of the food of an animal, and should be fed with care so that there may be no loss.

Protein and Carbohydrates.— These are two words that may seem difficult to understand at first, but they are really very simple. Use the words whenever possible,

and they will not seem so difficult. Have you ever made chewing gum by chewing the grains of wheat? This gum was made almost entirely of protein. It is called *gluten* in the wheat. In cheese, it is called *casein*. In the white of an egg, it is called *albumen*. Protein is found in all the field grains, in hay, in clover, in peas and in beans. It goes to form the flesh, the cartilage, the hair, the wool, and the casein and albumen of milk. It forms the material in the body that is used up when work is performed. *Carbohydrates* are principally the sugars and the starches. Granulated sugar is a pure crystallized carbohydrate. Potato is composed almost entirely of starch and sugar. The potato is a carbohydrate. Nearly all fruits and vegetables are carbohydrates. The grains have some starch in them, and that part of them is carbohydrate. The same may be said of hay, grass and fodder. The carbohydrates are chiefly valuable in keeping up the heat of the body and in forming fat.

Office of Protein and Carbohydrates.— Protein and corbohydrates may be likened to the coal that is put into the steam engine to give it power to do work. When the work is done, the substances are consumed or burned up. It is an interesting fact that the carbohydrates are much more easily consumed in the body than the proteins. When the body has work to do, or uses up fuel in keeping warm, it first calls on the carbohydrates for service. The proteins are not used until the carbohydrates are largely consumed; then the proteins are called on. If more carbohydrates be furnished than is necessary to keep the body warm and to furnish the energy for work, the body stores it up in the shape of fat. The dairy cow secretes it in the

udder; the beef cow and the hog lay the fat on over the muscles.

Fat.— Some foods, such as cotton-seed meal, linseed meal, nuts, etc., contain a considerable quantity of oil or fat. This is used by the animals for food in the same way and for the same purpose as the carbohydrates. It is, however, about two and one-fourth times as valuable in producing heat as the same quantity of carbohydrates.

EXERCISES.

1. Make a list of ten animal foods valuable chiefly for protein.
2. Make a list of ten foods valuable chiefly as carbohydrates.
3. Consult the Fodder Tables (in the Appendix) and arrange the foods in each list according to the relative amounts of protein and carbohydrate in each.

Feeding Standards.— It is evident from the lists that you have made that the most expensive foods are those valuable chiefly for the protein which they contain. The economical farmer will feed these foods as sparingly as possible and still produce the results he desires. It has been found by careful testing just what proportion of protein and carbohydrates it is best to feed an animal. For instance, it has been found that, for an average dairy cow, about six times as much carbohydrates as protein should be fed for the best results. This relation is usually expressed as a ratio, as 1 to 6 or 1 : 6, and is called the *nutritive ratio.* This means that, for every pound of protein, six pounds of carbohydrates should be given.

Chemists have determined the amounts of protein and carbohydrates in all of the common feeding stuffs. From tables prepared by them, we may "figure out" a ration with such foods as may be raised on the farm or purchased. It is sometimes more economical to sell certain feed, and to buy other feed that contains the elements needed to make a proper ration.

Balanced Ration.— A balanced ration is a statement of the quantities of various feeds that will provide a nutritive ratio that is proper. Suppose we wished to make a balanced ration for an average dairy cow. We find from the Table of Nutrients (in the Appendix) that such a cow needs daily about twenty-seven pounds of dry matter. She needs two pounds of digestible protein, eleven pounds of carbohydrates, and four tenths of a pound of fat. If we multiply the fat required by two and one fourth, it will be equivalent to about one pound of carbohydrates. The nutritive ratio, given in the Table of Nutrients, is 1:6. Suppose we have clover hay, corn stover, bran, corn meal, and cotton-seed meal, to feed.

	Dry matter.	Digestible protein.	Digestible carbohydrates.
Clover hay, 15 lbs..........	12.7	1.07	6.3
Corn stover, 7.5 lbs........	4.5	.11	2.5
Bran, 2.5 lbs...............	2.2	.30	1.2
Corn meal, 3 lbs............	2.6	.19	2.1
Cotton-seed meal, 1 lb......	.9	.40	.4
Result	22.9	2.07	12.5
Standard	27.0	2.00	12.0

Nutritive ratio, 1:6.

It must not be expected that a ration will figure out exactly according to the needs. The above ration is close

enough for all practical purposes. The "dry matter" is about five pounds short of the requirement, but that is not important. The figuring out of a ration for any animal is somewhat a matter of guessing.

Suppose we wish to figure out a ration for a horse at light work and weighing one thousand pounds. We have on hand mixed hay, oats and bran. How much of each may we feed, and make a balanced ration? Let us look first on page 221 of the Appendix, and we see that a horse weighing about 1,000 pounds, at light work, requires daily 20 pounds of digestible dry matter, 1.5 pounds of protein, and 10.4 pounds of carbohydrates (.4 lbs. $\times 2\frac{1}{4} + 9.5$ lbs.), making a ratio of 1:7. That is, seven times as many pounds of carbohydrates and fats as protein should be fed. This we might call a *medium* ratio.[1]

Now let us make a guess of a ration for our work horse. Let us take fifteen pounds of mixed hay and five pounds of oats, and see how close our result comes to the standard. From the Fodder Tables in the Appendix, we find our ration figures out as follows:

	Digestible dry matter.	Digestible protein.	Digestible carbohydrates.
15 lbs. Mixed hay........	12.7	.66	6.6
5 lbs. Oats..............	4.5	.46	2.8
Result	17.2	1.12	9.4
Standard	20.0	1.50	10.4
	Lacks 2.8	Lacks .38	Lacks 1

[1] The terms "medium" ratio, "wide" ratio and "narrow" ratio are used to indicate the relative amount of carbohydrates compared with the protein elements. A "wide" ratio means more of the carbohydrates as compared

The ration so far is lacking in food at every point. We must select foods for the remainder of the ration that have a wide ratio. Let us add three pounds of bran. This will produce the following result:

	Dry matter.	Protein.	Carbohydrates.
Previously obtained	17.2	1.12	9.4
3 lbs. Bran...............	2.6	.36	1.4
Result	19.8	1.48	10.8
Standard	20.0	1.50	10.4
	Lacks .2	Lacks .02	Excess .4

Comparing our result with the standard, we find that we still lack .2 lb. of dry matter of reaching the requirement, but this makes but little difference. It lacks .02 lb. of the amount required for protein. As this is a very important element, it might be well to select some other food, having a narrower ratio, such as linseed meal, to be given in small amounts. The amount of carbohydrates is close enough to the standard for all practical purposes. It is not necessary that the ration be brought exactly to the standard; but, in the amounts of protein and carbohydrates, it should not vary much from it. If the amount of dry matter vary two or three pounds either way, it will make but little difference.

Cost and Feeding.— The wise farmer will figure the cost of the different food stuffs very carefully to find out what is the most profitable to feed. It is often best to sell some of the foods having a wide ratio, such as hay

with the proteins, than the "medium" ratio; a "narrow" ratio means less of the carbohydrates. For a dairy cow, the ratio of 1:6 might be considered a medium ratio; 1:4, a narrow ratio; and 1:12, a wide ratio.

and potatoes, and to purchase foods having a narrow ratio, such as cotton-seed or linseed meal.

Manurial Value of Feeding Stuffs.— On account of the value of certain foods as manure, it is also necessary to figure on the manurial value of a food as well as on its feeding value. From the Table on page 261, it may be seen that some substances are of far greater value as manure than others, and this fact should be considered in making a profitable ration, and in determining what foods to sell and what to purchase.

PROBLEMS AND EXERCISES.

1. Make a ration for a milch cow of about 1,000 pounds weight, using silage, alfalfa, and wheat bran.

2. Suppose a farmer has ground oats, corn meal, mixed hay, and stover (cornstalks) on his farm. Could a balanced ration for a dairy cow be made from these alone? Select additional foods from the table to make a balanced ration for a dairy cow (1,000 lbs.).

3. If a farmer feed to a dairy cow of 1,400 pounds weight, 60 pounds of mature corn ensilage daily, how much of clover hay, corn meal, ground peas, wheat meal, and wheat middlings should be fed with it to make a balanced ration?

4. Make a ration for a dairy cow (1,000 lbs.), having the usual ratio of 1:6, of mixed hay, mangel-wurzels, corn meal, oats, wheat bran, and gluten flour.

5. A farmer fed his cows, averaging about 1,000 pounds each, 10 pounds timothy hay, 13 pounds stover, and 6 pounds straw. His cows averaged but 156 pounds of butter each year. Why does he get such poor results?

Suggest changes in the feed that would be likely to increase the amount of butter produced.

6. A herd of Shorthorns, weighing an average of 1,300 pounds, was fed daily as follows:

Mixed hay	10 lbs.
Stover	5 lbs.
Straw	5 lbs.
Turnips	15 lbs.
Corn meal	2 lbs.
Wheat bran	2 lbs.

What is the nutritive ratio of this ration? Suggest changes that would produce better results.

7. The nutritive ratio for a growing boy or girl with ordinary exercise is about 1 : 5.2. Make a good food ration for such a boy or girl from the table found on page 264.

8. A man at hard work on the farm should be fed a ration having a nutritive ratio of 1 : 6.9. Make a ration from the following: Baked apples, bread and butter, potatoes, boiled beef, and rice pudding.

9. The following made up the bill of fare of a hard-working farmer: White flour biscuit, molasses, butter, potatoes, and fat pork. Suggest changes and additions that will give him the food better adapted to his needs.

34. HORSES.

Breeds.— The different breeds of horses may be classed as follows:

1. Those valuable for speed.
2. Those valuable for drawing loads.
3. Those valuable as coach horses.
4. Ponies.

FIG. 103.— One of General Grant's Arabians.

Horses Valuable for Speed.— The *Arabian horse* was probably the origin of horses noted for speed. At present, it is not so speedy as many of the breeds which

have sprung from it. After General Grant made his trip around the world, he was presented with a fine team of Arabians. A picture of one of them is given (Figure 103).

The *Thoroughbred horse* is an animal of great endurance and great speed. The Thoroughbreds are running horses and are bred chiefly for racing. The breed was

FIG. 104.—Dan Patch, 1:56¼.

established in England by a mixture of native stock with Arabian.

The *American trotting horses* do not yet make a distinct breed, but they are better known than many of the distinct breeds. The most important families of this class

are Hambletonians, Mambrinos, and Clays. The Morgans, also, belong to this class, and are probably the most popular for general purposes.

Horses Valuable for Drawing Loads (Draft).— The draft horses differ chiefly from the horses valued for speed

FIG. 105.— Percheron stallion.

in being much heavier and larger. The back is broader and the legs are shorter. The chief breeds are here illustrated.

The Percheron was developed in France. When the

breed was first established most of the horses were dappled gray, but the largest number are now black or dark brown. The Percherons are good farm horses. They are gentle, active, and strong. The *French Draft* horse is similar to the Percheron.

FIG. 106.— Clydesdale stallion.

The *English Shire* horse is low, broad, and stout. It is not a very active breed and is adapted to drawing heavy loads with slow motion.

The *Clydesdale,* a native of Scotland, is a well muscled, well proportioned horse. Fine long hair grows from the edge of the lower legs. The Clydesdale has a rapid walk and is a very useful and popular farm horse.

Coach Horses.— These horses are in size and form between the speed horses and the draft horses, having some of the qualities of each. The chief breeds are the French Coach, the Cleveland Bay, the German Coach and the Hackney horse.

Ponies.— These horses are much smaller than other breeds.

Fig. 107.— Coach horses.

The *Shetland* ponies, originating in the Shetland Islands, near the west coast of Scotland, are bred for their small size. They are especially adapted for children's use.

The *Indian* ponies, in the northern part of the United States, and the *mustangs,* in the southern part, originated from the horses brought to this country by the early explorers from Spain and France. Both the Indian Pony and the Mustang are valuable as saddle animals.

Care of Horses.— The horse is a noble animal, of fine spirit and sensibilities, and requires careful treatment. Kind treatment and gentle handling will give the horse a good disposition, and will save money in feed besides. It will pay to figure out a good ration for the horse from the tables given in the Appendix. A well-balanced ration will keep a horse in good condition without over-feeding. Young people who have read "Black Beauty" will sympathize with the horse, and will give him the best of treatment.

FIG. 108.— Shetland pony.

SOME HORSE SENSE.

(From Biggle Book.)

Be gentle, be kind, be patient.

The brush will save oats.

If you must put frosty bits in some mouth, let it be your own. Suffering begets sympathy.

Many a horse stands up all night because his stall is not made so that he can lie down in comfort.

You can not whip terror out of a horse, or pound courage into one. If he shies or becomes frightened, soothe and encourage him rather than beat and abuse him.

A horse can travel safer and better if he is not checked too high. By all means let your working horse have his head.

35. SHEEP.

Breeds of Sheep.— Sheep are raised for their mutton and for their wool. The breeds are often classified according to the fineness of their wool. The fine-wooled sheep are the Merino, the Delaine, and the Rambouillet. The medium-wooled breeds are the Southdown, the

Fig. 109.— American Merino ram, four years old.

Shropshire, the Dorset, the Hampshire, the Oxford, and the Cheviot. The long-wooled sheep are the Leicester, the Cotswold, and the Lincoln.

Fine-wooled Sheep.— The *Merino* is a native of Spain, and is distinguished by the large wrinkles on its neck and body, and its fine, oily wool. The wool of this sheep is

Fig 110.— Cheviot ram.

finer than that of any other breed. The Merino is raised chiefly for its wool, though some families produce very

Fig. 111.— Southdown ram.

good mutton. Large numbers of Merinos are raised in the southwestern states of our country. They are particularly adapted to warm climates.

The *Delaine* is descended from the Merino. It is larger and stronger than the Merino, and is freer from wrinkles. This breed is coming in favor for its mutton.

The *Rambouillet,* or *French Merinos,* are the largest of the Merinos and have a mutton form. The fleece is not so heavy in proportion to the size of the sheep as the Merinos.

FIG. 112.— Shropshire yearling.

The *Cheviot* is a native of the hills between England and Scotland. It is a hardy breed and produces a wool adapted to make the cheviot cloth. The entire head and the legs are pure white.

The Medium-wooled Breeds.— The *Southdown,* the smallest of the medium-wooled breeds, is an English sheep. It is hornless, its head and legs being of a gray-brown color. The wool is of medium fineness, but the sheep is valuable chiefly for its production of mutton.

The *Shropshire* sheep takes its name from the county of

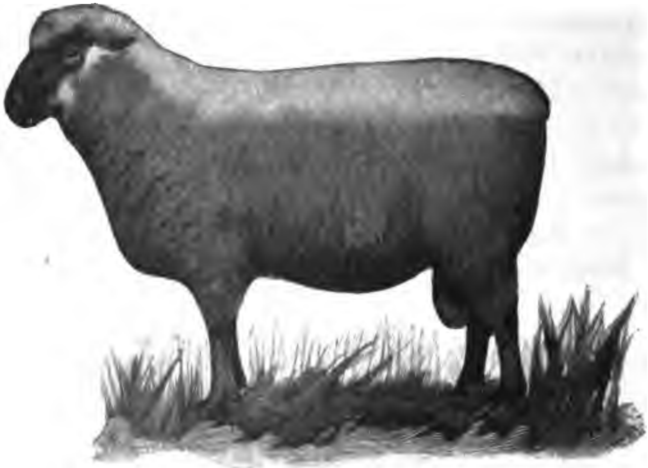


FIG. 113.— Hampshire-down ram.

the same name in England, where it was first brought to notice. It resembles the Southdown in appearance. It

FIG. 114.— Oxford-down ram.

is especially adapted for the lowlands, thus being probably the best all-purpose sheep for the central part of the United States.

The *Dorset* is valuable chiefly in producing winter lambs. Both the rams and the ewes have horns. They are considerably larger than the Southdowns. The head and legs are white.

The *Horned Dorset* is an English breed. Its nose,

FIG. 115.— Lincoln ram.

hoofs and legs are white, and it has a tuft of wool on its forehead. The Horned Dorsets are not so important or so widely distributed as the Merinos.

The *Hampshire* is similar to the Shropshire, but is larger and coarser.

The *Oxford* is the largest of this class of sheep. Neither the Hampshire nor the Oxford sheep are widely distributed in the United States.

The Long-wooled Breeds.— The Leicester, Cotswold,

and Lincoln are English sheep bred chiefly for their long wool. They are of large size and require rich pasturage. They are not popular breeds in the United States.

Advantage of Sheep Production.— Rough and scanty pasturage that would be too poor for other farm animals, may often be used to raise sheep. As a result, also, the fertility of the land is greatly increased, and weeds are kept down. The profits from sheep raising under favorable conditions are greater than those from raising stock of any other kind.

36. SWINE.

Breeds of Swine.— The different breeds of swine are divided into classes according to size. The most important breeds of hogs are the Berkshire, the Poland-China, the Duroc Jersey, the Tamworth, the Large Yorkshire, and the Chester White.

Fig. 116.— Texas razor back hog.

The Berkshires.— The Berkshires are black, with white markings on the head, feet, and sometimes on the front legs. The head is thick and short and the face is dished.

The Poland-Chinas.— This breed is black, with white markings on the head and feet. The head is short and thick, with slightly dished face and small, drooping ears.

The Duroc Jerseys.— These swine are red or light brown. They have short heads, with slightly dished

faces, and drooping ears. The body is compact and plump and resembles that of the Poland-Chinas.

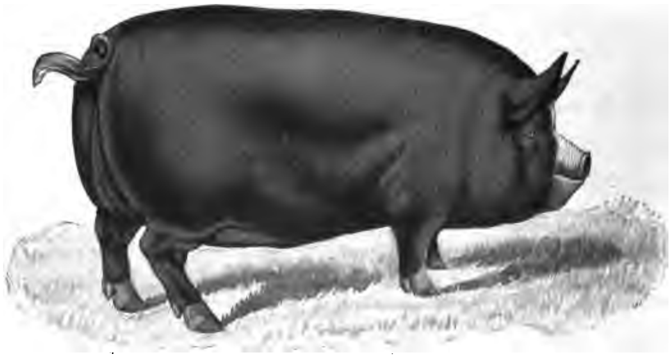


FIG. 117.— Berkshire hog.

The Large Yorkshires.— This breed is white. They have long, narrow bodies, medium length heads, erect ears, and much dished faces.

FIG. 118.— Poland-China hog.

The Tamworths.— These hogs are red or brown in color, like the Duroc Jerseys, but they have longer legs

FIG. 119.— Duroc Jersey hog.

and slimmer bodies than that breed. The nose is long and straight, and the ears are erect.

FIG. 120.— Tamworth hog.

The Chester Whites.— As the name indicates, these hogs are white. The head is short and slightly dished. The ears are drooping and the body is large and compact.

The Advantage of Swine Raising.— A pound of swine flesh can be produced more cheaply than a pound of flesh in any other farm animal. The hog is built so compactly that there is very little waste in slaughtering, and it will eat many kinds of food that could not be disposed of otherwise. If hogs are kept in clean quarters and are fed

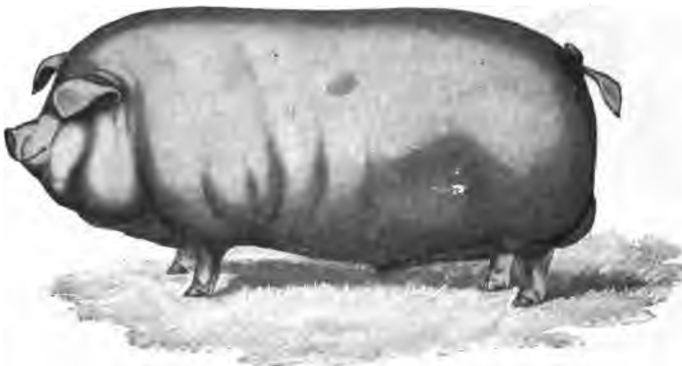


FIG. 121.— Chester White hog.

properly, they are not likely to become diseased. Under such conditions, hog raising is a profitable industry.

EXERCISES.

1. Make a ration, consisting of skim milk and corn, for a young pig weighing from fifty to one hundred pounds.

2. Make a ration, consisting of whey and middlings, for a hog weighing two hundred pounds.

3. A hog weighing one hundred and fifty pounds is to be fattened with corn and middlings. Make a ration adapted for this purpose.

37. POULTRY (Pl. II., III., IV.).

The Profit of Poultry Raising.— The importance of the poultry business has not been appreciated by the farmers. The value of the poultry and eggs produced in the United States in one year amounts to about one-half billion dollars. If proper attention were given to this industry on the farm, a much larger profit might be secured. A small flock of not to exceed fifty hens, with careful attention, will add a considerable amount to the farmer's income. It often happens that those who are unable to do heavy work on the farm may employ their time with profit in caring for poultry.

Breeds of Chickens.— It pays to keep nothing but pure bred fowls on the farm. The common or mongrel stock will eat just as much and will require just as much care as the pure bred stock, and, as a rule, they do not produce so well.

Chickens may be raised chiefly for the eggs which they lay. They are then called "egg breeds." They may be raised for their flesh. These are called "meat breeds." Both of these objects may be served, and the fowl belong to the "general purpose" breeds.

Egg Breeds.— The best known *egg breeds* are the Leghorn, the Minorca, and the Houdan.

The *Leghorns* may be brown, white, black or buff. They are rather small, nervous fowls, with large red combs and wattles. They are great layers, but they do

not sit. The Leghorns should not be kept in close confinement, but should be allowed a large range.

The *Minorcas* are either black or white. They, also, have large combs. Under proper conditions, they are extra good layers. The flesh is not regarded as the best for table use.

The *Houdans* are beautiful fowls. They have a topknot of feathers on the head and V-shaped combs. They have five toes on each foot instead of four, the usual number. They are good layers and non-sitters. Were it not for the fact that they are rather delicate, and that the topknots on the head prevent their seeing danger easily, they would be one of the most popular breeds.

Meat Breeds.— The *Brahmas* are the most important of the *meat breeds*. The Light Brahmas are the largest variety of fowl. They lay large brown eggs, and are good sitters. They bear confinement well, and are quiet in disposition. The legs and toes are heavily feathered. The Dark Brahmas are similar to the Light Brahmas, but are about one pound lighter in weight.

The *Cochins*, of which there are four breeds,— the Partridge, Buff, Black, and White,— are the hardiest of all the breeds. The feathers are heavy and extend down over the toes. The Cochins are good sitters and fair layers.

The *Cornish Indian Games* are a distinct meat breed. The meat on the breast is plentiful and delicious. They are poor layers, but good sitters.

The General Purpose Breeds.— The *Plymouth Rocks* are the most popular class of fowls in America. There are three breeds: the Barred, the White, and the Buff.

They are hardy, beautiful, good layers, and fairly good sitters. The meat is good for table use.

The *Wyandottes* are close to the Plymouth Rocks in popularity. Many think them the better fowl for general purposes. They have compact bodies, are fairly good sitters and are splendid layers. They lay dark eggs and are good table fowls.

Care of Fowls.— Choose a place for the poultry house that shall have good drainage. A southern or southeastern slope is best, so that the fowls may have plenty of sunshine, and be protected from the northwest wind.

FIG. 122.— A good hen-house with shed.

Build a snug, comfortable house for the chickens to live in at night. Houses that are comfortable save much grain, and encourage hens to lay in winter. Attached to the hen-house should be a larger, more open scratching shed. Make this large enough to furnish about four square feet of scratching surface for each hen. The scratching shed should open toward the south, so that the fowls may get the full benefit of the sunshine. In a sunny corner of the shed, a box, filled with fine dust scraped from the road in the summer time, should be placed. Chickens delight in the dust bath, and it helps

to free them from lice. The floor of the shed should be covered with chopped straw or chaff. The grain may be thrown in this to give the poultry proper exercise in scratching and picking it out.

Feeding.— As much care should be exercised in feeding chickens as in feeding a dairy cow. The balanced ration will give the best results. If the chickens are allowed to range over the farm, they will usually supply themselves with food that has the proper proportion of egg-forming and of fat-forming material. They will pick up grain, seeds, insects, and green blades of grass. When they are kept in a yard, these varieties of food should be supplied in proper proportions.

FIG. 123.— Homemade drinking fountain.

Chickens need plenty of pure water. This should be supplied in dishes that are cleaned regularly. A lard pail or other can may be filled with water and turned over suddenly in a shallow pan or in a flower-pot saucer. A little niche or hole near the edge of the pail or can will allow the water to flow into the pan or saucer as it is needed.

Poultry should have some green food, vegetables or cut grass, grain of some kind, preferably corn, and meat. It is necessary that meat be fed to the hens in the winter time, if they are expected to lay. The meat furnishes the albumen for the eggs. Beets or cabbage heads may be hung just out of reach of the poultry, so they must jump up to peck at them. This will furnish the green food

necessary in the winter, as well as giving the poultry needed exercise. Cracked oyster shells, crushed glass or other forms of grit, should be placed where the chickens can get all they want. This helps in the digestion of other food, and forms the bones of the poultry and the shells of the eggs.

Parasites.— Poultry are often afflicted with lice and with mites. The lice breed on the chickens, and live upon them. The mites live in the cracks in the roosts, in the nests, and in the walls. They come out in the night time and suck the blood of the fowls. To destroy the lice, sprinkle the chickens with insect powder frequently. To destroy the mites, the poultry house should be kept thoroughly clean. The entire inside of the house, including roosts and boxes, should be washed with coal oil every other week. Roosts, boxes, and platforms should be made movable, so that they may be taken out for thorough cleaning.

38. DUCKS AND TURKEYS (Pl. IV.).

DUCKS.

Ducks are easily raised on the farm. They eat much food that other animals will not touch. They can be

FIG. 124.— Pekin ducks.

raised just as well where there is no swimming pond, though they get much food from the pond if they have the chance.

Ducks are hatched best under a hen. She is also the best mother for them. Ducklings should not be allowed to go into the water for the first ten days.

Breeds of Ducks.— The Pekin duck is the best duck for profit. It is easily kept, is a good layer, and brings the highest price in the market. Its white feathers may be sold for a good price.

The *Rouen* duck is beautifully colored, and is probably descended directly from the wild duck,— the Mallard.

The *Cayuga* is jet black in plumage, and originated in New York.

The *Aylesbury* is the favorite English variety. It is pure dead white.

TURKEYS.

Wild turkeys were quite plentiful in America before it was well settled. The turkey on our farms was derived from the wild turkey.

The meat of the turkey is more desired than that of any other fowl, and it brings the highest price in the market.

The turkey is of a roving disposition, and does not do well when kept in a small enclosure. It is best not to attempt to keep turkeys in a poultry house. They thrive better when allowed to roost outdoors.

The turkey hen seeks an out-of-the-way place to lay her eggs. She goes far from the house to make her nest and to rear her young. Sometimes turkeys go a half a mile or more and make their nests in a fence corner or in a brush heap. They may be enticed to nest nearer home by setting a few boards or an old door against a fence corner, and throwing a bunch of hay under it, or by placing barrels and boxes with hay in them on the

ground in some secluded spot. The young turkeys, or poults, as they are called, are very delicate, and, until they are ten or twelve weeks old, they should be cared for in coops. They should not be let out of the coop in the morning until the dew is off the grass.

The Bronze Turkey.—This is the largest, the most popular, and the most profitable of all the breeds. The gobblers weigh about thirty-six pounds, and the turkey hens about twenty pounds. This breed furnishes the largest part of the turkey meat for Thanksgiving and Christmas feasts.

39. BEE-KEEPING.

Bees and Flowers.— Every country boy or girl knows that nectar is gathered by bees. These little workers fly about from flower to flower, collect the nectar drop by drop, with wonderful industry and patience, and carry it home, where, after freeing it of much of the water which it contains, and adding a preservative acid, they store it away in regular tiers of waxen cells. Then when the weather is so cold that they can not leave the home, they have food on which to live. Bees do not injure the

Worker. Queen. Drone

FIG. 125.—Honey bees.

flowers which they visit. On the contrary, they help them to bear more seed and fruit. Our orchards and berry fields yield more and better fruit because of the bees.

Social Life of the Bees.— Wild bees live in hollow trees, or sometimes in crevices in rocks; but the honey of the market is gathered by tame bees,— that is, by bees that are kept on the farm. Bees live in large families or colonies, each of which has its queen. Each colony, or, as it is frequently called, "swarm," lives in its own house or "hive," and the bees of one hive are not wel-

come in another. Each worker bee is armed with a sting, with which to protect its home, but the skilful bee-keeper learns to control his bees so that they do not often use their stings.

The Workers, the Queen, and the Drone.— The worker bee is the smallest bee in the hive. It takes the little scales of wax that form between the rings on the abdomen and makes the comb. The oil which is made from the food eaten by the bee finds its way through the bee's body and hardens into waxy scales. The bee plucks a wax scale from its abdomen with its leg-pinchers and passes it forward to its mouth, where it is chewed. The wax is then ready to be made into the six-sided cells which make the comb. The workers also fill the cells with the honey which they make from the nectar of the flowers. The cells are not all of the same size. Some are made for holding honey; others in which the queen lays eggs, are sometimes used also to hold honey or pollen, often called beebread. This beebread is a sticky mass that the bees make by moistening the pollen which they gather from flowers. It is of various colors and somewhat sweetish to the taste.

The queen bee lays her eggs in three separate sets of cells, placing one egg in each cell. In the small cells, she lays eggs that are to become the workers; in the cells next larger, she lays the eggs that will become drones when they are hatched. Finally, she lays a few eggs in some large cells built on the edge of the comb. These are called royal cells, and the eggs in them may hatch queens if they are furnished with the proper kind of food by the workers.

The drones, as you might think from the name, do not gather honey; neither do they have stings. They are the male bees in the hive, and the workers, after the harvest is ended, drive the drones out of the hive and let them starve, or sting them to death if they attempt to return.

Life in the Hive.— In every hive or colony of bees, there are more worker cells than any other kind, for it is the busy workers that make up the colony. Among these, there are a great many that act as nurses in the hive. These nurse bees take charge of the larvæ and feed them. As the larvæ lie curled up in their cells, they look like little white worms. The nurse bees constantly feed the larvæ; first, when young, a sort of "bee-milk" secreted by glands in their own heads, and, later, when the larvæ are older, a mixture of this secretion with honey and pollen, or, at last, only honey and pollen. When the larvæ have eaten all they need, they straighten out their small bodies and the workers put a cap on the cell, made up of wax, mixed with gnawings of cocoons, pollen grains, and silk threads. This is porous and permits air to reach the developing insect. Each larva then spins a silken cocoon about itself and goes to sleep in its waxen cradle.

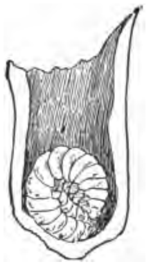


FIG. 126. — Larva of bee.

It takes usually twenty-one days from the time the egg is laid until the perfect worker bee casts aside its silken wrap, gnaws open the cell cover and comes out with four thin wings. The young queens develop in about sixteen days; but drones require twenty-four days.

Many of the honey cells are left open a week or more after they are filled; for the bees will not cap them over with wax until they know that the honey in them is "ripe," or ready to be sealed up. So it is always easy for the young bee to find an open cell where it can eat all it wants.

When a few days old the workers act as nurse bees, and fly out only for exercise, but, in a couple of weeks they gain full use of their wings and go outside to work with the older bees. It is well that it begins its work at once, for the length of a worker bee's life is but a few months at most, and some of them live only a few weeks. Queen bees, however, have been known to live four or five years.

A great many bees in the hive die during the winter; but the queen bee begins to lay her eggs in midwinter or very early in the spring, and those eggs hatch out so fast that the number in the hive is soon as large as ever. A large number of young bees come out of the cells every day during the hatching season, which lasts through the warm summer months, and thus the hive is always kept full.

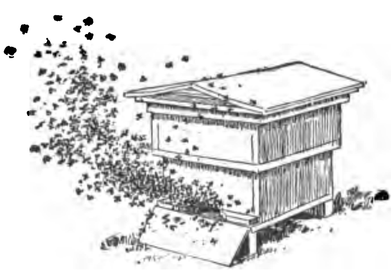


FIG. 127.—Beehive.

Swarming.— As soon as the oldest queen-cell is sealed, the old queen often leaves the hive, and a large number of bees follow her. This is called "swarming." The bees protect the immature queen-cells until the eldest queen emerges, which usually occurs a week after the first swarm issues. Should the

colony be sufficiently strong, this young queen will lead out a second swarm, and, in case no further swarming is decided upon, the next queen which emerges will be permitted, and even assisted, by the workers in destroying the remaining queen-cells. The bee-keeper often takes advantage of this opportunity to secure from the numerous cells formed, surplus queens for colonies that have chanced to lose their own.

If the new queens are not removed as soon as they come out of their cells, the ruling queen will seek them out, and sting them to death.

When the bees "swarm," they gather about the queen in a black, buzzing mass, and may alight on the limb of a tree. As soon as possible, spread out a white cloth under the tree. Set upon this a clean, cool hive and shake the bees in front of it, propping up the hive so as to let them enter. The limb may be cut from the tree with the adhering bees, or they may be shaken directly into a large basket and poured out in front of the empty hive. A comb containing unsealed brood, if placed in the hive, will serve as a great attraction to them. Their strong sense of smell will guide them toward it and they will enter their new home joyfully. Plenty of air should be given at both the top and bottom of the hive, since the bees are usually much heated by the excitement of swarming.

FIG. 128.—Honeycomb.

Comb Honey and Extracted Honey.— In a modern bee-hive, each comb is built by the bees in a movable frame, so that the bee-keeper can remove the combs at will.

After the hive is well stored with honey, small frames on sections are placed over the brood chamber of the hive for the bees to fill with comb and honey. Honey in the cells is called "comb honey."

Sometimes the combs are removed from the hive as fast as they are filled with honey, and placed in a machine called a "honey extractor." Here they are caused to revolve so rapidly that the honey is thrown out of the cells. It then appears as a thick liquid like syrup, and is called "extracted honey."

The combs are then replaced in the hive for the bees to fill again with honey. Bees do not like to see empty cells in their hive, and they will work very hard to fill them. The extracting process, therefore, causes bees to make more honey than they would if the honey were left in the cells.

Sources of Honey.— Although many kinds of flowers yield some honey, the honey that bees store up in their hives is mostly secured from a few kinds. White and alsike clovers, alfalfa, basswood, raspberry, sourwood, sweet clover, white sage, black mangrove, tulip or "poplar" trees, buckwheat, and asters yield the greater part of the honey on the market. Honey bees are able to secure only a small part of the honey from flowers of the red clover.

Crops are not often grown on purpose for bees, as this would not generally prove profitable.

Profits in Bee-keeping. — In sections where honey-yielding flowers are numerous, and not too many bees are kept, bee-keeping may often be made a profitable addition to the industries of the farm. The bees gather their honey wherever they can find it, and no one disputes their right.

Bee-keeping by modern methods requires watchful care and skillful management. The work connected with it is, however, very light, and is easily performed by women.

With good management, bees yield a considerable income to the owner. It is necessary, however, to protect them from their enemies, shelter them through the winter, and furnish them with sufficient food when the flowers are not in blossom.

Races of Bees. — There are numerous breeds or races of bees: the common brown or black bees, the Italians, the Carniolans, the Cyprians, the Syrians, and the Caucasians. The first two are most widely spread and much intermixed throughout the country. Any bees possessing black blood should be avoided, because of their spitefulness and inability to defend their hives wholly against the wax moths and other bee enemies. They are also less industrious than the Italians. The Carniolans are quite prolific, excellent honey gatherers and very gentle; being quite hardy, they winter and breed well in the coldest of climates, and their comb honey is of snowy whiteness. The Cyprians gather the most honey and are the best defenders of their hives, but require quite skillful handling, as they are very vindictive when aroused. The Syrians are similar, but not superior, to the Cyprians.

The Caucasians, recently introduced by the United States Department of Agriculture, are the gentlest of all known races, and may be kept on the lawn or in the flower garden and handled at any time without protection and with no fear of stings; they are also diligent workers, and produce honey equal to that of any of the others.

40. IMPROVEMENT OF HOME AND SCHOOL YARDS.

Home and School Yards.— It is not enough that our farms produce large crops to be sold at good prices and the business thus be made profitable. We should also look to our surroundings. We should have good, comfortable, well-arranged homes, and the grounds about them should be made as attractive as possible. We shall be better men and women if we live in beautiful surroundings than if we live in poorly-kept and ugly quarters. Schoolhouses and school yards, too, should be made as beautiful as possible. A great many people would be glad to have beautiful homes and schoolhouses and fine yards if they but knew how to obtain them at small cost. School children who are interested can do much toward beautifying the entire neighborhood in which they live.

A few general directions are given that may help in making our homes and our schools delightful places in which to live.

Make a Plan.—It is well to make a plan before attempting any change of things as they are. This will make it easy to do part of the work this year, to add to it next year, and so on until the plan is carried out. Without a plan, we may make improvements that we shall find do

not lend beauty to our surroundings, and our work will be entirely lost. Do not make a very complex plan. A simple one, with few details, is much better.

Natural Features.— Many places have some natural features that aid in the work of beautifying them. A clump of trees, a small hill, a stream of water, or a pond, found on the place, should be used in the plan you make. Do not try to get rid of such things, but lay out a plan that will use them to the best advantage.

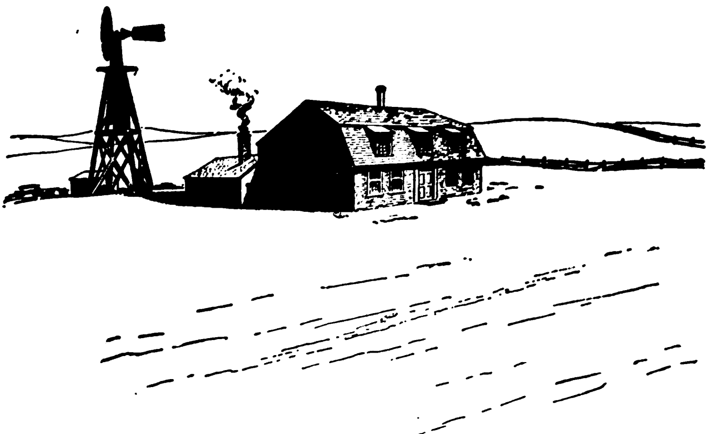


Fig. 129.— A problem in landscape gardening.

The House the Important Part.— The house should usually be the most important part of the plan. It need not be in the middle of the lot, but other things should be so grouped about it as to set it off. So often we see a house rising boldly from the center of a yard, with no adornment whatever. Here we see such a house in all its loneliness. It looks cheerless, and no amount of money spent on it will make it look homelike, unless the

shrubbery, the trees, and the yard in general are planned to make the house a part of the whole.

FIG. 130.— A solution of the problem in figure 129.

In Figure 130, the house is made a part of the general out-of-door plan.

FIG. 131.— Evergreen trees should not be trimmed. (P. 214.)

Open Front Yards.— Very often we find that the yard in front of a house is filled with shrubbery or with flower beds. It is far better to leave the space in front of the house entirely open. The house is then shown to much better advantage, and the yard is much more easily cared for. There is nothing much more pleasing than a well-kept front lawn.

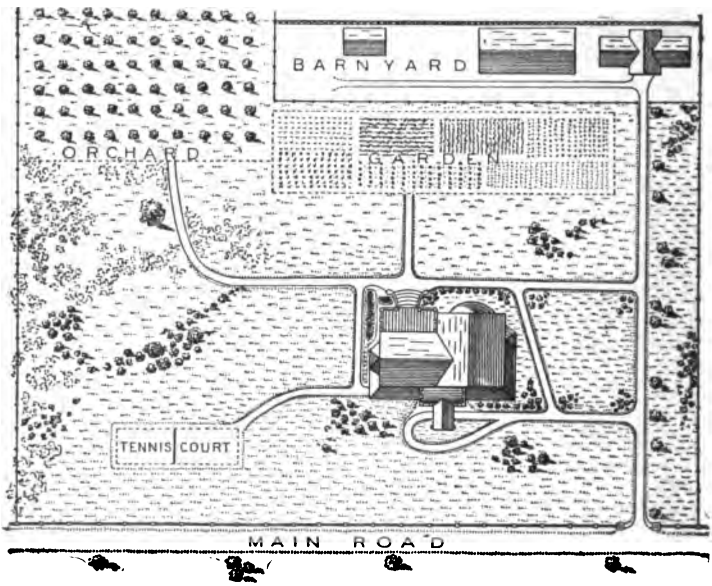


FIG. 132.— Too many straight paths.

Shrubbery and Flowers.— The shrubbery should be arranged in masses, and not with the shrubs placed singly. Let the branches grow thickly, so as to make a mass of green. These masses should be placed on the border of the yard. With the flowers, they make a fine

frame for the "picture" we are trying to make. Shrubs may be placed, also, so as to hide outbuildings or to form a screen for the backyard.

Flowers may be planted close to the house or just in front of the shrubbery. They should not be planted in separate flower beds in the lawn.

Vines.— Vines may be used to cover old fences, or to

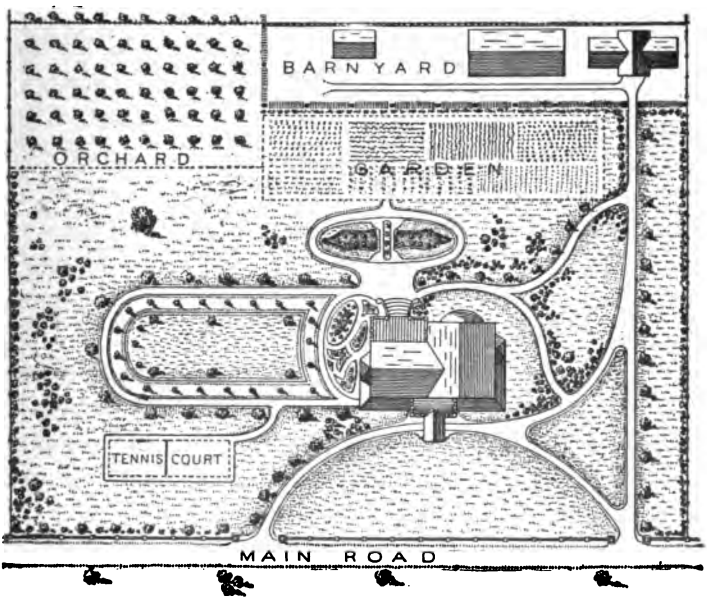


FIG. 133.— Suggestion for improving the plan of paths shown in figure 132.

clamber over old or unpainted buildings, with very good effect. With vines alone, an unpleasing place may be changed to a very beautiful one. Vines are also useful in helping to make the house a part of the "picture."

Trees.— Trees may be planted in groups about the

yard. They should be placed so as to be of some use, either in giving shade or in forming a wind break. Evergreen trees and hard wood trees should not be planted in the same group. If evergreen trees are planted, they should not be trimmed and the lower branches should not be cut. They look much prettier in their natural condition (Figure 131).

Paths.— There should be as few paths as possible, and these should be placed so that they will be the most convenient. Care should be taken to avoid straight lines in laying out the paths. Sometimes a straight path is necessary from the street to the house, but, when it is possible, the paths should be made on large easy curves.

Barns and Other Buildings.— It is not easy to tell just where and how the barns, stables, granaries and other farm buildings should be placed. Much depends upon local conditions.

The barns and stables should not be placed very close to the house, but at such a distance that the barnyard odors and the flies will not be troublesome. The garden, however, may be placed quite near the house, so that it may be easily tended and watched.

If the barns and stables are built in the form of a hollow square, with one side left open, they will give protection against the winds in winter and will furnish shade in summer

School Yards.— The school yards should be models for the whole community. Even if the schoolhouse is not a fine building, it may be made very attractive by improvements. The principles of landscape gardening

which have been given for homes apply also to school yards.

In the country, where land is cheap, there is no reason why the school should not be supplied with a large plot of land. This will furnish room for a lawn and for a good-sized playground. In many places, also, one part of the school ground may be set apart for a school garden, where plants of different kinds may be raised and where the principles of plant growth may be taught. Unless

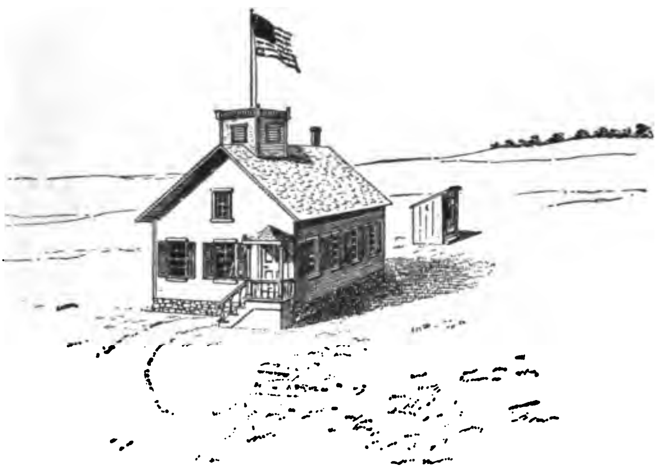


FIG. 134.— A bare school yard.

some arrangement is made for the care of the school garden during the summer vacation, however, it is likely to become a garden of weeds.

The picture shown in Figure 134 is a very common one, much more common than it should be. Notice how bare and cheerless it is.

In Figure 135, we see what has been done with the

school yard to make it attractive and homelike. The teacher and the pupils in the school did all the work, and, with no expense, made this wonderful improvement. The shrubbery and trees were obtained by the boys from the woods. Flower seeds and bulbs were given by the parents and were planted by the girls under the direction of the teacher. All worked together to make the school yard beautiful, and were very proud of the result.

FIG. 135.— A suggestion in planting.

EXERCISES.

1. Make a general plan for the improvement of your school grounds, observing carefully the suggestions given.

2. Make a plan for the improvement of the yards about your home, allowing buildings, fences, and trees to remain as they are at present.

3. Make a plan for the improvement of your home yards, making such changes in the location of buildings, fences, and trees as you think best.

APPENDIX.

HELPFUL FACTS AND FIGURES.

Directions for Using the Babcock Test.

Sampling the Milk.— Great care should be taken to have the sample of milk represent as nearly as possible the whole lot from which it was taken. Milk fresh from the cow, while it is still warm and before the cream has separated in a layer, may be thoroughly mixed by pouring it three or four times from one vessel to another. Samples taken at once from milk mixed in this way give the best results. Milk that has stood until a layer of cream has formed should be poured a greater number of times so that the cream shall be thoroughly broken up and the whole appear like milk. No clots of cream should appear on the surface when the milk is left quiet for a minute.

Measuring the Milk.— When the milk has been well mixed, the milk pipette is filled by placing its lower end in the milk and sucking at the upper end until the milk rises above the mark on the stem; then remove the pipette from the mouth and quickly close the tube at the upper end by firmly pressing the tip of the index finger upon it so the milk cannot flow from the pipette. Holding the pipette up straight, with the mark on a level with the eye, carefully admit air slowly to the space above the milk, till the upper surface of the milk falls to the mark upon the stem. Always have the upper

end of the pipette and the finger dry when measuring milk, as it is almost impossible gradually to lower the milk if the finger is wet. Next, place the point of the pipette in the mouth of one of the test bottles, held in a slightly slanting position so that the milk can flow down the side of the tube, and remove the finger, allowing the milk to flow into the bottle. After waiting a short time for the pipette to drain, blow into the upper end to expel all the milk.

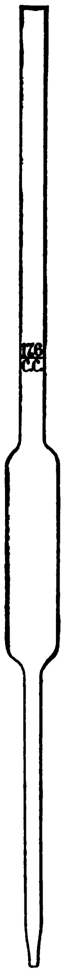


FIG. 136.— Pipette.

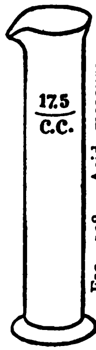


FIG. 138.— Acid measure.

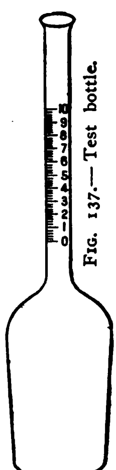


FIG. 137.— Test bottle.

Adding the Acid.— When the milk has been measured into the test bottles, the necessary amount of acid may be added immediately or the bottles may be left for a day or two without materially changing the results.

The amount of acid required for a test is about the same as that of the milk, 17.5 c. c. for the ordinary test. If too little acid is added, the casein is not all held in solution throughout the test, and an imperfect separation of the fat results. If too much acid is used, the fat itself is attacked. Great care must be taken in handling the acid to avoid getting any of it on the skin or clothing.

The acid measure is filled to the 17.5 c. c. mark with acid, which is then carefully poured into a test bottle containing milk. The bottle should be held in a slightly slanting position so that the acid may flow down its side and not come in contact with the milk too suddenly and thus act upon it unevenly. The acid being heavier than the milk, sinks directly to the bottom of the test bottle without mixing with the milk, which floats upon it. The acid and milk should now be thoroughly mixed by being gently shaken with a rotary motion. The mixture becomes quite hot and soon changes to a dark brown color.

Whirling the Bottles.— The test bottles containing the mixture of milk and acid may be placed in the machine directly after the acid is added, or they may be allowed to stand several hours without harm. An even number of bottles should be whirled at the same time, and they should be placed in the wheel in pairs opposite each other. When all the test bottles have been placed in the apparatus, the cover should be placed upon the jacket and the machine turned at such a rate that the wheel carrying the bottles shall make from 700 to 1,200 revolutions per minute. This motion must be kept up for six or seven minutes.

Adding Hot Water.— As soon as the bottles have been sufficiently whirled, pour in enough hot water to bring the mixture up to the bottom of the neck. Put the bottles into the machine and whirl them again for about three minutes. Now pour in enough hot water to bring all the fat up into the neck of bottle, where it may be measured.

Measuring the Fat.— To measure the fat, take a bottle from its socket, and, holding it in an upright position

with the scale on a level with the eye, observe the divisions which mark the highest and lowest limits of the fat. The fat should be read from the extreme top of the curved upper surface, and not from the bottom or middle of the same. The difference between these divisions gives the per cent of fat directly. The reading can easily be taken to half divisions or to one-tenth of one per cent.

Example.— If the figures on the necks of the bottles gave the per cent of butter fat, for example, as from 0 to 3, there would be three per cent. The spaces between the figures represent one per cent, and each space between the lines represents two tenths of one per cent. Thus, if the bottom of the oil in the neck of the bottle stood at the figure 2 and the top of the third fine line above the figure 6, there would be four and six tenths per cent (4.6 per cent). Each per cent represents one pound of butter fat in one hundred pounds of milk.

Amount of Butter.— It must be remembered that the Babcock Test gives only the amount of butter fat in the milk or cream, and that the butter itself contains several substances besides butter fat, so that the amount of butter shows an increase of from ten per cent to eighteen per cent. Hence, in figuring the amount of butter made, this increase should be added to the amount of butter fat which is shown by the Babcock Test.

Silage.

Grass, clover, corn fodder and cow peas, when fed in the green state, are relished by farm animals much more than after they are cured. Much of the nutriment of plants is lost in the process of curing and the matter is

made less digestible. It has been found that corn fodder loses nearly one fourth in digestible matter by being allowed to cure in the field. Although grass, clover and fodder can not be kept in their fresh green state by being put in a silo, they can be preserved in this manner so that they undergo only slight changes.

Green fodder put in a

Fig. 139.— Silo.

silo ferments a little and often changes to a dark brown color. It is called *ensilage*, or more properly, *silage*. The word silage is also used often for corn silage. Any green matter may be put in a silo. Besides corn silage, which is the most common form, clover silage, cow-pea silage, alfalfa silage, beet silage, and soja bean si-

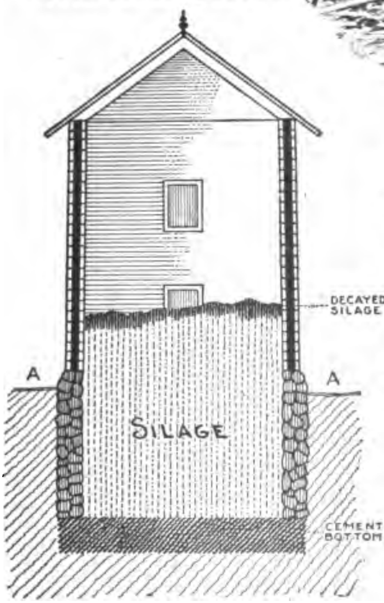


Fig. 140.— Section of Silo.

lage are often made. To make the silage more easily handled and more easily eaten by the cattle, the fodder is usually made fine by cutting before it is put in the silo.

A silo may be built inside or outside the barn. It may be built above the ground or it may be dug in the ground like a cistern. The matter of greatest importance is to make the silo air-tight. If air is admitted, the silage decays and becomes unfit for use.

Round silos, built either of brick, of cement, or of wood, are becoming very popular. They hold more silage than square silos of equal size. The silage settles more evenly in them, also, and there is no loss from decayed silage in corners. The silage at the top of a silo decays and forms a pasty mass which prevents the air from passing through to the material below. This thin layer of decayed silage serves as an air-tight cover for the silo.

Number of Tons of Corn Silage in Cylindrical Silos.

Depth in Feet.	Inside Diameter in Feet.							
	16	17	18	19	20	21	22	23
25	90	104	116	129	143	158	173	189
26	97	110	123	137	152	167	184	201
27	103	116	130	145	160	177	194	212
28	108	122	137	152	170	186	204	226
29	114	128	144	160	178	196	215	235
30	119	135	151	168	187	206	226	247
31	125	141	158	176	195	215	236	258
32	136	148	166	185	205	225	247	270

Townships and Sections.

How to Describe Land.— The United States Government has surveyed a large part of the land in this country. An understanding of the system will enable one to locate any piece of land accurately.

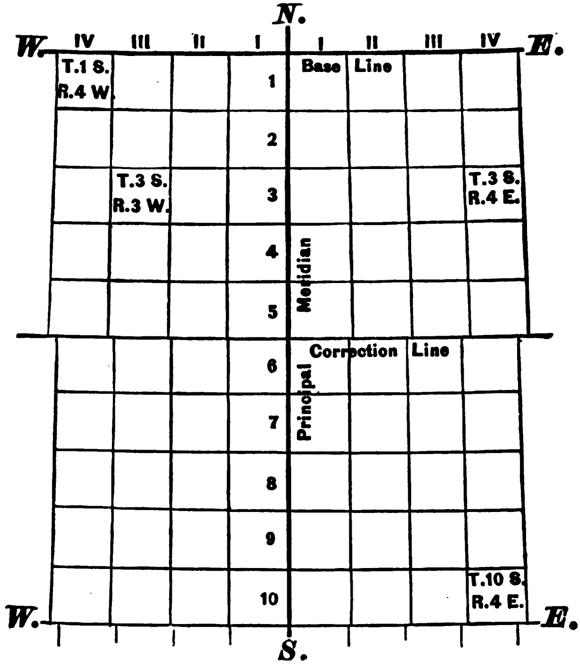


FIG. 141.— U. S. Land Survey.

The government first establishes two lines from which to commence the survey. A line, called a *Principal Meridian,* is run north and south, and a line, called a *Base Line,* is run east and west across the principal meridian. Commencing with the principal meridian, distances of six miles are measured off on the base line, and, from

these points lines are run directly north and south. Commencing with the base line, distances of six miles are measured on the principal meridian, and lines through these points are run east and west parallel with the base line. These lines, north and south, and east and west, divide the land into townships. These are about six miles square, and contain about thirty-six square miles each.

A row of townships running north and south is called a *Range*.

Lines running north and south converge toward the north; i. e., they get closer together as they run north. The townships some distance north of the base line are therefore narrower than those south of them. To avoid making townships too narrow for practical use, a *Correction Line* is run east and west. From this line, the survey commences again. It is a new base line.

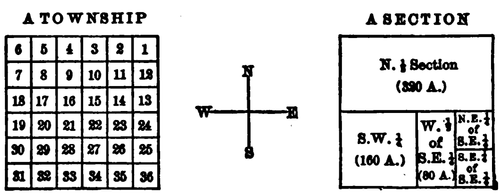


Fig. 142.

In Figure 141, the town in the southeast corner is described as Town 10 South, Range 4 East. This is usually written, T 10 S, R 4 E.

A township contains about thirty-six square miles, and is divided into thirty-six squares called Sections. The sections are numbered consecutively, commencing in the northeast corner, as shown in the diagram.

The sections are made full size on the south and east

rows. When the township contains less than thirty-six full sections, the north and west sections are not full size.

A full section contains 640 acres, and is divided into halves, quarters, etc., as shown in the diagram. The upper 40-acre piece is described as the Northeast quarter of the Southeast quarter (written N. E. ¼ of S. E. ¼). The 80-acre piece is the West half of the Southeast quarter (written W. ½ of S. E. ¼).

Exercises.— With the atlas or sectional map of your county and state before you, describe the quarter section in which the schoolhouse is situated.

Make diagrams on paper or on the blackboard, showing the location of each of the following, telling the number of acres represented in each case:

N. E. ¼ of S. W. ¼ of Sec. 16, T 4 N, R 3 E.
N. ½ of N. W. ¼ of Sec. 36, T 7 N, R 5 W.
E. ½ of N. E. ¼ of N. W. ¼ of Sec. 22, T 5 S, R 2 E.

Describe the 10-acre piece on which your home is located.

Contents of Fields and Lots.

The following table will assist in making accurate estimate of the amount of land in different fields under cultivation:

10	rods	x	16	rods	1 A
8	"	x	20	"	1 A
5	"	x	32	"	1 A
4	"	x	40	"	1 A
5	yards	x	968	yards	1 A
10	"	x	484	"	1 A
20	"	x	242	"	1 A
40	"	x	121	"	1 A
80	"	x	60 1-2	"	1 A
70	"	x	69 1-7	"	1 A

220	feet	x	198	feet	1 A
440	"	x	99	"	1 A
110	"	x	396	"	1 A
60	"	x	726	"	1 A
120	"	x	363	"	1 A
240	"	x	181 1-2	"	1 A
200	"	x	108 9-10	"	1-2 A
100	"	x	145 2-10	"	1-3 A
100	"	x	108 9-10	"	1-4 A

Space and Quantities of Seed Required.

Name.	Space and Quantity of Seeds.
Asparagus	1 oz. produces 1,000 plants, and requires a bed 12 ft. square.
Asparagus Roots	1,000 plant a bed 4 feet wide and 225 feet long.
English Dwarf Beans	1 quart plants from 100 to 150 feet of row.
French Dwarf Beans	1 quart plants from 250 to 350 feet of row.
Beans, pole, large	1 quart plants 100 hills.
Beans, pole, small	1 quart plants 140 hills or 250 feet of row.
Beets	10 lbs. to the acre, 1 oz. plants 150 feet of row.
Broccoli and Kale	1 oz. plants 2,500 plants, and requires 40 sq. ft. of ground.
Cabbage	Early sorts same as broccoli, and require 60 sq. ft. of ground.
Cauliflower	The same as cabbage.
Carrot	1 oz. to 150 feet of row.
Celery	1 oz. plants 2,500 plants, and requires 40 sq. ft. of ground.
Cucumber	1 oz. for 150 hills.
Cress	1 oz. sows a bed 16 feet square.
Egg Plant	1 oz. gives 2,000 plants.
Endive	1 oz. gives 3,000 plants, and requires 80 sq. ft. of ground.
Leek	1 oz. gives 2,000 plants, and requires 60 sq. ft. of ground.
Lettuce	1 oz. gives 7,000 plants, and requires a seed bed of 120 sq. feet.
Melon	1 oz. for 120 hills.
Nasturtium	1 oz. sows 25 feet of row.
Onion	1 oz. sows 200 feet of row.
Okra	1 oz. sows 200 feet of row.
Parsley	1 oz. sows 200 feet of row.
Parsnips	1 oz. sows 250 feet of row.
Peppers	1 oz. gives 2,500 plants.
Peas	1 quart sows 120 feet of row.
Pumpkin	1 oz. to 150 hills.
Radish	1 oz. to 100 feet.
Salsify	1 oz. to 50 feet of row.
Spinach	1 oz. to 200 feet of row.
Squash	1 oz. to 75 hills.
Tomato	1 oz. gives 2,500 plants, requiring a seed bed of 80 sq. feet.
Turnip	1 oz. to 2,000 feet.
Watermelon	1 oz. to 50 hills.

Quantities of Seed Required to the Acre.

Name.	Quantity of Seed.	Name.	Quantity of Seed.
Wheat	1¼ to 2 bushels.	Broom Corn	1 to 1½ bushels.
Barley	1½ to 2½ bushels.	Potatoes	5 to 10 bushels.
Oats	2 to 4 bushels.	Timothy	12 to 24 quarts.
Rye	1 to 2 bushels.	Mustard	8 to 20 quarts.
Buckwheat	¾ to 1⅓ bushels.	Herd Grass	12 to 16 quarts.
Millet	1 to 1½ bushels.	Flat Turnip	2 to 3 pounds.
Corn	¼ to 1 bushel.	Red Clover	10 to 16 pounds.
Beans	1 to 2 bushels.	White Clover	3 to 4 pounds.
Peas	2½ to 3½ bushels.	Blue Grass	10 to 15 pounds.
Hemp	1 to 1½ bushels.	Orchard Grass	20 to 30 pounds.
Flax	½ to 2 bushels.	Carrots	4 to 5 pounds.
Rice	2 to 2½ pounds.	Parsnips	6 to 8 pounds.

Weights of Grain, Seeds, etc.

The table given below shows the weight of grain, seeds, etc., per bushel, as established by the Legislatures of the states named:

Articles	New York	Ohio	Pennsylvania	Indiana	Wisconsin	Iowa	Illinois	Michigan	Connecticut	Massachusetts	Rhode Island	Kentucky	New Jersey	Vermont	Missouri	Minnesota
Wheat	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Rye	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Corn	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Oats	32	32	32	32	32	32	32	32	32	32	32	32	30	32	32	32
Barley	48	48	47	48	48	48	48	48	48	48	48	47	48	48	48	48
Buckwheat	48	50	48	50	48	52	52	48	48	48	48	56	50	48	52	50
Clover Seed	60	64	60	60	60	60	60	60	..	..	60	60	64	60	60	60
Timothy Seed	45	45	..	45	45	45	45	45	..	..	45	45	..	45	45	45
Flax Seed	55	46	..	56	55	56	56	56	..	..	56	56	55	..	44	56
Hemp Seed	44	44	..	44	44	44	44	44	..	..	40	44	..	..	44	50
Blue Grass Seed	14	..	..	14	14	14	14	14	..	..	14	14	..	..	14	14
Apples, Dried	25	24	..	25	28	24	24	22	..	..	..	24	25	..	24	28
Peaches, Dried	33	33	..	33	28	33	33	28	..	..	..	39	33	..	32	28
Coarse Salt	56	50	85	50	..	50	..	..	..	..	..	50	..	..	50	56
Fine Salt	56	50	63	50	..	50	..	..	..	..	..	50	..	..	50	56
Potatoes	60	60	56	60	60	60	60	60	60	60	60	60	60	60	60	60
Peas	60	..	..	..	60	..	..	60	60	60	60	60	60	60	60	60
Beans	60	60	..	60	60	60	60	60	60	60	60	60	60	62	60	60
Castor Beans	46	..	..	46	..	46	46	46	..	..	..	..	..	..	46	..
Onions	57	55	50	48	57	57	57	54	50	50	50	57	57	52	57	52
Corn Meal	50	..	..	50	50	..	48	50	50	50	50	..	..	..	50	..

Plowing.

Showing the distance traveled by a horse in plowing an acre of land:

Breadth of Furrow Slice Inches	Distance Traveled in Plowing an Acre Miles
7	14½
8	12½
9	11
10	9 9-10
11	9
12	8¼
13	7½
14	7
15	6½
16	6⅙
17	5¾
18	5½
19	5¼
20	4 9-10

To Find the Number of Bushels in a Bin or Crib.

Multiply together the length, breadth and height in feet, and multiply this product by .8.

Two cubic feet of good dry corn in the ear will make a bushel of shelled corn.

To Find the Number of Tons of Hay in a Mow or Rick.

In Mow: Multiply together the height, length and breadth in feet, and divide the product by 350 for wild hay, by 450 for timothy hay, and by 600 for clover hay.

In Rick: Multiply the length by the breadth, and that product by half the difference between the breadth and the distance over. This will give the number of cubic feet. Divide as above to find the number of tons.

To Find the Area of a Circle.

Square the diameter (multiply the diameter by itself), and multiply by .7854.

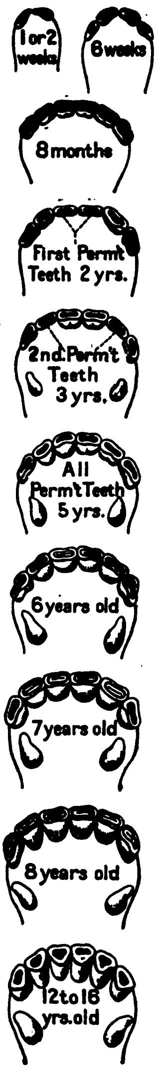
How to Tell the Age of a Horse.

The appearance of a horse's teeth is a pretty sure indication of his age.

The first year, the colt cuts its twelve front teeth and sixteen grinders. They all show the mark on the grinding surface.

At the end of the second year, the marks on the two front teeth (the nippers) are much worn out, and the next two teeth are somewhat worn.

At the end of the third year, the horse has lost his four front baby teeth, and at the end of the fourth year, all the baby teeth are replaced by permanent teeth.



The fifth year shows the nippers grown long, and the sharp edges worn down somewhat.

The sixth year shows the dark marks in the nippers on the lower jaw worn out.

Seven years find the four front teeth worn.

Eight years find all the teeth worn, so that the marks in the centers can not be seen.

At nine, the upper nippers have almost lost the marks. At this age, also, the upper corner teeth show curves in their surfaces.

At ten, the marks in the middle upper teeth have changed from oblong to nearly circular. At eleven, all of the upper teeth show the same change.

At twelve, the lower nippers have become nearly round. At thirteen, the middle lower teeth are nearly round; at fourteen, all are round.

At fifteen years, the upper nippers are rounded; at sixteen, the upper middle, and, at seventeen, all the uppers have the same shape. At eighteen, the lower nippers become three-cornered; at nineteen, the middle ones.

At twenty, all the lower teeth are triangular.

How to Obtain Agricultural Literature.

Besides the large number of agricultural papers that are available for the farmer at very small cost, the Department of Agriculture issues a large number of interesting documents, many of which are sent free to any who apply for them, while some others may be obtained for a small price.

Write to the Department of Agriculture, Washington, D. C., and request a list of the publications issued by the Department for free distribution.

"The Farmers' Bulletins" are probably the most helpful publications issued by the Department of Agriculture. There are over two hundred issued and the number is being increased rapidly. From the list which you receive from the Department you may select such as interest you and request them sent to you. You may write to your Congressman for them or to the Department of Agriculture.

Each year the Department of Agriculture issues a fine illustrated "Year Book." This may be obtained free by application to the Congressman of your district or to either of your United States Senators.

If you have an Experiment Station in your State, find its location and write to the "Director of Experiment Station," requesting that your name be placed on the permanent mailing list to receive all the bulletins issued by the station.

You may also request such bulletins as you know to have been issued by the Station. They will be sent free of cost.

More About Nitrifying Bacteria.

Crop Rotation.—In chapter nine explanation is given of the way that clover and others of the legumes help the farmer to enrich the soil. It was there shown that the tubercles on the roots of the legumes were the abiding places of certain bacteria which, through their activity, change the nitrogen of the air into nitrates. The nitrates are the most important of the food elements taken in through the roots of the plant. All farm crops require a large amount of nitrates; hence when the crops are removed the soil soon becomes poor because of the loss of the nitrates. It is for this reason principally that all careful farmers practice crop rotation, using one of the legumes in the rotation to supply the nitrates that have been removed.

Pure Cultures of Bacteria.—Careful investigations by the Department of Agriculture and by some of the Experiment Stations have shown that sometimes the legumes will grow without the bacteria forming tubercles on the roots, or if the bacteria and the tubercles are present they have lost their activity in changing the nitrogen of the air into nitrates. When these are the facts, these plants are of little or no service in improving the fertility of the soil. It has been found, also, that in many places certain legumes will not grow well because of the absence of nitrifying bacteria. Scientists have now found a method of growing bacteria of the proper kind in their pure state. These are called "pure cultures," and may be used for inoculating soil that does not possess them or in which they are not active. By growing them on

substances that have no nitrogen the bacteria are forced to obtain their supply from other sources, in this way becoming very active in their tendency to obtain nitrogen from the air.

How the Bacteria are Preserved.—A pure culture of the nitrifying bacteria is made in liquid form. Absorbent cotton is placed in this liquid and then removed to dry. The bacteria remain on the fibers of the cotton in countless numbers. Of course, they are too small to be seen, but they are there and will remain for a considerable time without change, much the same as a seed may be kept awaiting favorable conditions for germination.

The Department of Agriculture will, on application, send out these pure cultures free to farmers that need them for inoculating the soil so that it will produce any legume crop. The dry culture sent out needs only to be placed in water to start the bacteria into growth. To hasten the growth and to make it more certain, two packages of food for the bacteria are sent with the cotton culture.

With the food thus supplied two days gives a growth sufficient to change clear water into a milky liquid. Full and simple directions accompany these packages, and no difficulty need be experienced in preparing the liquid cultures.

Applied to the Soil.—After the liquid culture has been prepared it should be applied to the soil. A number of methods may be used. It may be sprinkled in its liquid state over the field, or a quantity of dry soil may be sprinkled with the liquid, and this soil may be scattered over the field. The most convenient method, how-

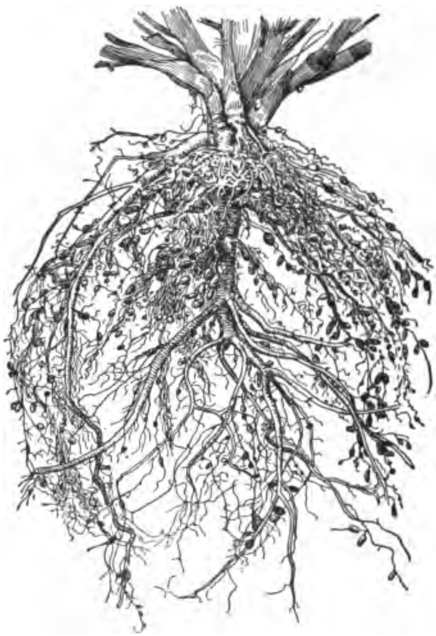
ever, is to inoculate the seed. The seed that is to be planted may be placed in a sack and the whole lowered into a tub or a barrel of the liquid culture so that each seed is wetted. It is then drained and spread out on a clean floor to dry. This does not injure the seed in any

Roots of young alfalfa plants, showing nodules. (From Farmers' Bulletin No. 214.)

way. The bacteria remain on the outside of the seed ready to become active on the rootlets when the seed germinates.

Inoculation for Legumes Only.—It is useless to apply the inoculating material to any other crop than the

legumes, or the pod-forming plants. The principal legumes used on the farms are mammoth and red clover, white clover, alsike clover, crimson clover, alfalfa, peas, beans, cowpeas, soy beans, and vetches. Corn, wheat,



Roots of red clover, showing nodules. (From Farmers' Bulletin No. 214.)

oats, rye, potatoes, and other plants that do not form pods for their seeds are not benefited in any way by the use of the inoculating material.

If the soil is supplied with nitrifying bacteria and is growing healthy crops of legumes, very little is gained by soil inoculation. It is well to dig up some of the

roots, however, and observe whether they have the nodules or tubercles.

Legumes grown in soils very rich in nitrogen will not show tubercles on the roots, even though there be a thrifty growth. The legumes are of no particular value

Roots of soy bean, showing nodules. (From Farmers' Bulletin No 214.)

on such soils. It would be more economical to grow the legumes on the poorer soils and use the soils already rich in nitrates for some other crops.

Transfer of Soils.—It is possible to inoculate soils from the soil of another field that is growing the legume successfully. Soils from a field growing any particular kind

of a legume may be used to inoculate soil of another field where it is desired to grow the same kind of plant. The soil from a clover patch would probably have no effect on a field which was expected to raise a crop of beans. It has been found in many cases, however, that the soil from a field of sweet clover will inoculate the soil successfully for a crop of alfalfa.

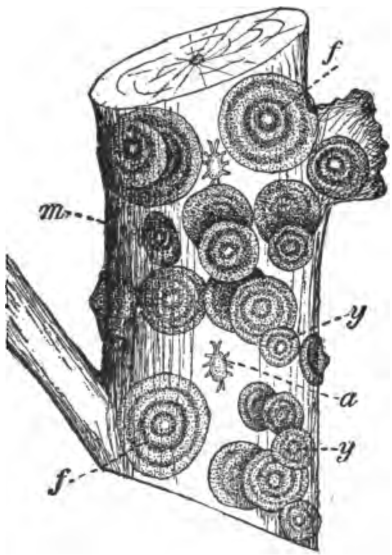
The transfer of soil from one field to another is not only a difficult matter, but it may spread certain plant diseases and foul weed seeds. As the Department of Agriculture is so generous as to furnish the pure cultures free of cost, it is folly to depend on other methods of inoculation.

What May be Expected.—Many people have been led to believe that soil inoculation will largely transform the methods of agriculture. Such hopes are not well founded. Careful cultivation, attention to climatic and other conditions are just as necessary now as before the method of inoculating the soils was discovered. All that can be claimed is that a wise use of this aid in the growth of legumes will without doubt result in much more successful results in growing the "nitrogen gatherers," and will enable the farmer to make a crop rotation that will enrich his soil year by year instead of wearing it out.

More facts concerning this subject may be obtained from Farmers' Bulletin No. 315. This bulletin may be obtained without cost by writing to the Department of Agriculture, Washington, D. C.

Additional Facts Concerning Insect Pests and their Treatment.

The San José Scale.—One of the most troublesome pests in the orchard is the San José scale. It does not look like an insect at all. Little gray or black specks in patches on the limbs or on the trunks of fruit trees are all that may be seen. Under these scales are the little animals that are doing the damage by sucking the juices of the plant. Most of the states of the Union have laws forbidding the shipping into the state of nursery stock that is infected with this pest. It spreads very rapidly through an orchard when it is once introduced. The surest way to prevent its spreading is to burn the affected trees.



San José scale insect; *m*, male scale; *f*, female scale; *y*, young scale; *a*, young insect. Enlarged.

There are other methods of destroying the scale which, if carried out with great care and thoroughness, may kill the scale and prevent its spreading. One of the most successful methods is by spraying with the lime and sulphur mixture (p. 242). This should be applied in the spring before the buds are open.

The Chinch Bug.—The chinch bug does a great deal of damage to grain and grass crops. It is more destructive to wheat and corn than to other crops, and more destructive when the summer is dry than when it is wet. In some places entire crops are destroyed by this pest.

These bugs spend the winter in litter that is about the farm; corn shocks make very good winter quarters for them. Where such hiding places are left, the bugs are ready to come out in the spring in large numbers and attack the green, growing grain.

Photograph of chinch bugs enlarged three times.

The best way to get rid of this pest is to keep the fields well cleaned of rubbish. Fall plowing would be of service in destroying their winter quarters. If the outer rows of corn are not planted and millet is sown early as a border about the corn field, the chinch bug will remain in the millet, leaving the corn plants untouched.

When these bugs are known to be traveling toward any locality, the fields may be protected by plowing a deep furrow about them. As the chinch bugs do not use their wings for flight, they are caught in the furrow and may be killed by spraying with a kerosene emulsion.

The Hessian Fly.—Next to the chinch bug, the Hessian fly is probably the most destructive to our growing grain. This is a small insect, about one-sixth of an inch in length. It thrives best in cool, moist weather. The great damage is done by the insect in the larval stage preceding the "flaxseed" stage. The "flaxseeds" are found between the leaf sheaf and the stem of the wheat. The

stem is weakened so that it is liable to be broken near the point where the "flaxseed" has attached itself.

Fall plowing will usually keep this pest in check. Fields that cannot be plowed in the fall should be burned over in the spring just before plowing.

Photograph of the Hessian fly, twice natural size. The flaxseed or pupa is at the base of a stalk of wheat from which the leaves are stripped down.

Since the fly lays its eggs near the place where it comes from the "flaxseed," wheat should not be planted on the same field two years in succession.

Directions for Preparing Insecticides and Fungicides.

Bordeaux Mixture.—Directions are given on page 59 for the preparation of Bordeaux mixture in small quantities. Below are given directions for larger quantities:—

4 lb. copper sulphate.
4 lb. fresh lime.
50 gal. of water.

Dissolve the copper sulphate and slake the lime as shown on page 60. Dilute each to 25 gallons, and pour together, making 50 gallons of the mixture. Spray. Use for apple and plum rot; potato, melon, celery, strawberry, and tomato blight; plum pockets, currant and grape anthracnose.

Paris Green or Arsenate of Lead.—Directions for preparation and use of Paris green are given on page 58. Arsenate of lead is somewhat safer than Paris green, and is not so liable to burn the foliage.

Directions: Dissolve 11 oz. acetate of lead (sugar of lead) in 4 quarts of water in a wooden pail, and 4 oz. arsenate of soda in a quart of water in another wooden pail. Pour the solutions together and add enough water to make 150 gal. (Instead of making the arsenate of lead solution, a market preparation such as disparene may be used in the proportion of 3 or 4 lb. to 50 gal. of water.) Sprinkle or spray.

Use for codling moth, tent caterpillar, potato beetle, and all other biting insects.

Bordeaux Mixture and Paris Green or Arsenate of Lead.—It is usually wise to make a combination mixture, and get rid of the fungi and the biting insects that may be destroying the leaves or fruit at the same time.

To each 50 gal. of Bordeaux mixture add 4 oz. of Paris green; or, to each 50 gal. of Bordeaux mixture add 1 gal. of the arsenate of lead solution before it is diluted with water. Spray.

Kerosene Emulsion.—See page 58.

2 gal. kerosene.
½ lb. common soap.
1 gal. water.

Dissolve the soap in hot water, add the kerosene, and churn together until a white creamy mass is formed which thickens on cooling. Dilute with nine times the amount of water before using. If it is more convenient, 1 gal. of

sour milk may be used with 2 gal. of kerosene. Dilute as before. Spray.

Use for plant lice and all other kinds of soft-bodied sucking insects.

Formalin.—See page 60.

A. One-half pint of formalin (formaldehyde) with 15 gal. of water. *B.* One pint of formalin with 50 gal. of water.

Use for: *A.* Potato scab. Soak the seed potatoes two hours in this solution before planting. *B.* Smut on grain. Soak the grain used for seed in this solution from one to two hours before planting.

Hellebore is not poisonous to man, so it may be used in place of Paris green when it is applied to parts of the plant that are to be eaten. It may be dusted on the plant, or 1 oz. of hellebore may be mixed with 2 gal. of water and sprayed on the plants.

Use for currant worm, rose slugs, and other sawfly larvæ.

Common Soap.—See page 58.

1 lb. common soap.
8 gal. water.

Spray upon foliage.

Use for red spider, plant lice, and other sucking insects.

Carbon Disulphide.—Gophers may be killed with the fumes of carbon disulphide. Soak cotton with the liquid, put it in the gopher hole, and plug it up tight to keep in the fumes.

Ant hills may be destroyed by pouring the liquid into holes made by a stick thrust into the hill. The hill should then be covered with a wet blanket to keep in the fumes and allowed to remain for twenty-four hours.

Insects in closed bins may be killed with the fumes of this liquid. Use 1 pint for each 100 bu. of grain.

Caution: Do not use this liquid in the presence of fire. It is very inflammable and its fumes are explosive.

Lime and Sulphur Mixture.—

20 lb. of lime.
14 lb. of sulphur.
40 gal. of water.

Boil one hour and apply while still warm. This must be applied before the buds come out in the spring. It will destroy buds and foliage.

Use for San José scale.

Hydrocyanic Acid Gas.—

1 oz. cyanide of potash.
2 oz. sulphuric acid.
4 oz. water.

For each 100 cu. ft. of space.

This gas is used for killing insects in rooms that may be closed tight. Nursery stock is freed of all insect pests by placing it in a room where this gas is generated. A room should be thoroughly ventilated for at least ten minutes before entering after the gas has been used. This is so poisonous a gas that it is safer to have the fumigation done by an expert or one who has had experience with it.

Sticky Fly Paper.—If a ring of any sticky substance is placed about the trunk of a tree, it will prevent insects climbing up to eat the foliage or to lay their eggs. Strips of sticky fly paper may be used for this purpose.

Use for the cankerworm.

SEMITROPICAL FRUITS, IRRIGATION, AND DRY FARMING

(Prepared by Professor Riley O. Johnson, State Normal School, Chico, California. He gratefully acknowledges the aid of Professors E. J. Wickson, E. W. Hilgard, and C. W. Woodsworth, all of the University of California.)

No family orchard in California is thought complete without at least one or two of the citrus fruits, such as oranges and lemons, and a few olive and fig trees. These are known as semitropical fruits because they grow in warm, yet not tropical, climates. In the United States, they can be grown with profit only in California, Florida, and the delta region of the Mississippi River, therefore there is always a good market for the product. Besides the fruit they produce, the trees themselves are quite ornamental, and they also give abundant shade. They are often grown for these purposes alone.

The citrus fruits cultivated in California include the orange, lemon, lime, grape fruit, and citron.

The Orange.—The orange is the most profitable of the citrus fruits that can be raised in California. Though it is now grown chiefly in the southern part of the state and in the Sacramento Valley, yet there are doubtless small regions in other parts of the state well suited to its growth, even in large enough quantities for the market. It remains for some of the boys and girls of the state to find out, by trying, just where these places are.

What the Orange Tree Needs.—The orange prefers a deep, rich, mellow soil, although it will grow well in nearly every kind of fertile soil.

The spot chosen for experimenting must be warm enough

so that there are no severe frosts to be feared, at least no hard freezing.

The orange orchard must be protected from winds either by hills or a grove of other trees.

There must be plenty of water. If nature does not supply enough, the soil must be irrigated. (See page 248.)

Orange trees must be carefully pruned (cut back) during the season when the tree is not bearing fruit. Only the dead branches and those no longer useful should be cut off. There is great danger of cutting away too much. The natural shape of the crown of the tree must be kept, as the fruit and the leaves grow on the ends of the branches.

The Lemon. — The lemon likes best a sandy loam, though it will grow well in other soils also. While the lemon does not require the heat necessary to produce the best oranges, it will not, at the same time, stand so much cold as the latter. The root of the orange tree will thrive in a greater variety of soils than will the root of the lemon tree, therefore it is quite common to graft the lemon (page 84) on an orange seedling stock.

Owing to its spreading habit, the tree must be carefully pruned. If this is not done, the fruit will be borne at the end of the long, willowy branches, and it will then be impossible to cultivate the ground as it should be.

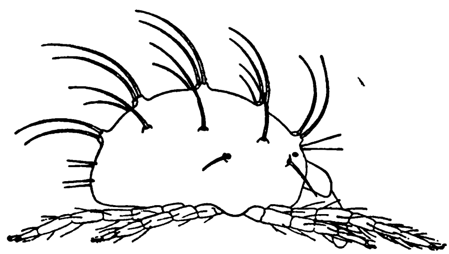
Enemies of the Orange and the Lemon

Scale Insects. — Chief among the insect enemies of these fruits are the soft scale, the red scale, and a variety of the latter, called the yellow scale.

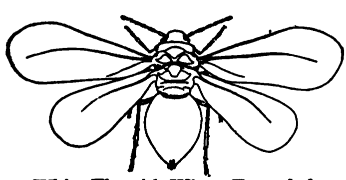
If you look on the under side of the leaves, you may find

these insects along the large veins. Here they insert their beaks and suck the sap which is being carried upward to the leaves and the prepared food which the leaves send downward to the other portions of the plant. Scale insects are also sometimes found on the fruit itself.

If the tree is sprayed with an emulsion of kerosene or is fumigated with hydrocyanic acid gas, these insects will disappear.

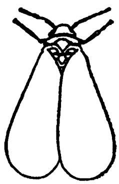

Red Spider. (From Station Bulletin, Berkeley, Cal.)

Red Spider. — In some places where these fruits are raised, the red spider has become a serious pest. The male spider is much smaller than the female. The female lays from twelve to eighteen bright red eggs, which are fastened to the under side of the leaf with threads of fine silk. These eggs hatch out in about two weeks, and the young spiders begin at once to suck the juice from the leaf. When grown, their bodies are covered with spines, which protect them from their enemies, the ladybird beetles and the lace-wing flies.


White Fly with Wings Extended.

White Fly. — This pest of citrus trees was unknown in California until a short time ago. As yet it has appeared in but a few places. Although called a fly, it is not one, since it has four wings, and the fly has only two. It is a near relative of the scale insects, but it does more damage because

it has wings. It can easily be told from the other pests found on citrus trees, because it is snow-white when full grown.



White Fly with Wings Closed.

When the wings are at rest, the insect is about the size of the letter *o* used in this paragraph.

The remedy is a severe one, for the pest is hard to get rid of. The tree must be stripped of its leaves and thoroughly fumigated before the insect is grown, or nothing can be done to save the tree.

Diseases of Citrus Trees

Gum Disease. — This disease, which usually affects the trunk of the tree near the ground, sometimes comes as a result of letting irrigation water come in contact with the stem of the tree. By keeping this water from touching the tree, one cause of the disease will be removed.

Other causes, still unknown, however, are likely to produce the disease. From whatever source the trouble comes, the portion of the bark which is diseased must be cut away, also the diseased wood beneath, and the wound covered with something, such as rubber paint, which will keep the sap from running out. Removing the soil from the lower part of the trunk is also helpful.

Chlorosis. — This disease causes the leaves of the tree to turn yellow. In the case of the orange and lemon it is commonly brought about by the lack in the subsoil (page 34) of some food element that the tree needs, or else by there being too much of some one element. Orange and lemon trees require lime, but many California soils have in them more lime

than is needed. Since it cannot be taken out, the only remedy is to plant the orchard in a soil that has less. Limy soils are generally of a whitish color, but the way to be certain is to take a little of the subsoil and pour on it a few drops of nitric acid. If many bubbles are given off, lime is probably present in large quantities, and oranges and lemons will not thrive well in this ground.

The Olive

The olive does best in a well-drained soil, though, like the orange and the lemon, it will yield good crops in a variety of soils. It prefers warm, dry climates, but will withstand some frost. It can be grown from buds, seeds, grafts, tips of twigs, cuttings, sprouts, suckers, and layers, but because it is a slow grower, the first three methods are not often used.

Olive trees do not begin bearing until about eight years of age. They have been known to live to be a thousand years old and to attain a height of forty feet.

The fruit is sometimes pickled in brine and sometimes dried. Great quantities are also grown for the oil which is very abundant in the fruit. The tree is very free from insect enemies and is useful as an ornamental as well as a shade tree.

The Fig

No fruit can be grown more generally over the state of California than the fig, and no other with so little care and risk. This tree will thrive well on any soil one would think of selecting for any of the common orchard trees, though it will succeed on a wider range of soils than will any of the others. It will bear well in any climate warm enough to

ripen the fruit and not cold enough to kill the tree. The fig should have plenty of moisture, but not too much.

In the orchard, the trees should be set forty or more feet apart, unless they are to be thinned later, as the tree is a wonderful spreader. If planted this far apart, smaller fruit trees may be planted between the rows and removed after several years, when the fig trees are in need of the room. In pruning, little except the cross branches need be cut off after the shape has become outlined. Not more than three limbs should be allowed to grow out from the trunk, and these should be well placed around it.

Fig trees begin bearing at from two to three years of age, and several crops a year are produced. Like the olive, the fig has few insect pests. Its worst enemy is the gopher, which gnaws away at the roots, sometimes to such an extent that the tree topples over.

Irrigation and Dry Farming

Irrigation. — In California, especially in the southern part, there are vast tracts of land where rain never falls. These are commonly known as arid regions. There are other great areas, in the Sacramento and San Joaquin valleys especially, where rain falls only during the winter season. In order that crops may be grown in the arid portions of the state, it is absolutely necessary that water be supplied by some means. The process by which water is supplied other than by natural means is called *irrigation.*

Methods of Irrigating. — Water for this purpose is often obtained from wells, and sewage from cities is sometimes used on farms lying near, but most of the water used comes from streams. When there is any likelihood that the stream from

which the water is taken will dry up during the season when water is needed, reservoirs are built so that a greater part of the winter rainfall may be used. Quite a number of methods of applying water by irrigation are in use in California, but those most common are *sprinkling*, *flooding*, and by *furrows*.

Sprinkling. — Of the three methods named, this one most nearly resembles the method by which nature furnishes water to growing plants. But in spite of this fact, sprinkling is no doubt the poorest of the three methods. To apply a sufficient amount of water at one time by this method requires a very slow application for a long time, for if applied too rapidly, the ground, if it is not sandy, becomes packed and hardened. In this condition air, which the plant needs, cannot get through the soil, and the roots also find it difficult to push through it. There is also very rapid evaporation from the surface unless the soil is stirred soon after the sprinkling. This results in great waste of moisture, and a second sprinkling is necessary in a short time. If practiced in regions where there is no rainfall in summer, it must be repeated often and a sufficient amount put on to wet the soil to a considerable depth. Otherwise the plant will develop a shallow root system and will be completely dependent upon water thus applied all through the growing season. On the other hand, plants which have a deep-rooting system are often able, after a while, to draw their needed supply of moisture from the water in the subsoil.

Flooding. — This method is used only where an abundance of water can be had and where the land to be irrigated is quite level or can be made so. As in the case of sprinkling, there will be rapid evaporation unless the surface of the

ground is stirred soon after the water is put on. A great disadvantage in this method is the long time necessary in order to put on enough water to do any good. This is necessarily so because of the fact that the air in the soil prevents, after a little, the rapid soaking up of the water, as the increasing weight of the water prevents the escape of the air in that direction. This method might be used to advantage in connection with the system of dry farming described later in this chapter.

Furrow System of Irrigation

The Furrow Method. — Of all the methods of irrigation, this one is most commonly used in California. One of its chief advantages lies in the fact that by it the subsoil becomes so soaked that a deep-rooting system is developed. By this method, water reaches the surface of the ground only by capillary attraction (page 18), hence the soil does not become so packed as to shut out the air and hinder the roots from growing downward.

The furrows should usually be run off from three to eight feet apart, depending, of course, on the nature of the soil, that is, as to its readiness to soak up water. This may easily be determined by experiment before the furrows are laid out. After the water has been shut off from the furrow and the surface has become dry enough, the furrow should be filled again to prevent too rapid evaporation. Losses due to this cause often amount to as much as 50 per cent of the water applied. Experience has proved that wide and deep furrows are much better than narrow and shallow ones. Where the former are used, it is possible to fill the furrows much sooner after irrigation, thus preventing great loss by evaporation, and the water also sinks to a greater depth in the soil, thus rendering it unnecessary to apply the water so often.

Dry Farming. — In the semiarid regions of the western part of the United States, where the rainfall for the entire year is not enough to mature a crop, a system of cultivation known as "dry farming" is coming to be practiced more and more. It should not be inferred from the name that by the practice of this system plants are able to thrive on smaller quantities of water than in other cases. The system consists in carefully preserving the moisture which falls during an entire year. During this year the land is not sowed to crops, but is so treated as to permit of a very small amount of evaporation. The surface is constantly kept loose, being stirred after each rain of any considerable amount. Before planting, a machine called a subsurface packer is run over the ground. This machine consists of a number of wheels placed five inches apart on a shaft, each wheel being eighteen inches in diameter. The rim of each wheel is one inch thick

at the inner part, and is slanted two and a half inches to a sharp outer edge. A weight of about five hundred pounds is so placed as to make these wheels sink well into the ground, packing the soil quite firmly beneath the surface and leaving the surface itself loose and mellow. A mulch (page 56) is thus formed which reduces evaporation to the least possible amount. After the crop is planted, the soil is kept loose at the surface until the crop is matured. The moisture preserved through one year by this system is often sufficient for the maturing of crops through three or four following years. If practiced in moist regions during dry years, this system would add greatly to the yield.

The principles of dry farming might be put to good use in both the arid regions of California and those regions where there is a good winter rainfall. In the former areas, where land can be flooded, one application of water would be enough for an entire season. In regions having a winter rainfall, the moisture could be so preserved that irrigation would be wholly unnecessary, and heavy yields would result each year.

CONVENIENT TABLES.

FODDER TABLES.

Pounds of Fodder	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.
Grasses	**Pasture Grass, 1:4.8**			**Timothy Grass, 1:14.8**			**Red Top Grass, 1:14.6**			**Kentucky Blue Grass, 1:9.2**		
2½	0.5	0.06	0.3	1.0	0.04	0.5	0.9	0.03	0.5	0.9	0.05	0.5
5	1.0	0.12	0.6	1.9	0.08	1.1	1.7	0.07	1.0	1.8	0.10	0.9
10	2.0	0.23	1.1	3.8	0.15	2.1	3.5	0.13	1.9	3.5	0.20	1.8
15	3.0	0.35	1.7	5.8	0.23	3.2	5.2	0.20	2.9	5.2	0.30	2.7
20	4.0	0.46	2.2	7.7	0.30	4.3	6.9	0.26	3.8	7.0	0.40	3.7
25	5.0	0.58	2.8	9.6	0.38	5.4	8.7	0.33	4.8	8.7	0.50	4.7
30	6.0	0.69	3.3	11.5	0.45	6.4	10.4	0.39	5.7	10.5	0.60	5.5
35	7.0	0.81	3.9	13.4	0.53	7.5	12.1	0.46	6.7	12.2	0.70	6.4
40	8.0	0.92	4.4	15.4	0.60	8.6	13.9	0.52	7.6	14.0	0.80	7.3
Grasses and Green Fodders	**Alfalfa, 1:3.6**			**Green Fodder Corn, 1:11.7**			**Sweet Fodder Corn, 1:11.3**			**Green Barley Fodder, 1:5.7**		
2½	0.5	0.10	0.4	0.5	0.03	0.3	0.5	0.03	0.3	0.6	0.06	0.3
5	1.0	0.20	0.7	1.0	0.06	0.6	1.0	0.06	0.7	1.2	0.12	0.7
10	1.9	0.41	1.4	2.1	0.11	1.3	2.1	0.12	1.4	2.5	0.24	1.4
15	2.9	0.61	2.2	3.1	0.17	1.9	3.1	0.18	2.1	3.7	0.36	2.1
20	3.9	0.81	2.9	4.1	0.22	2.6	4.2	0.24	2.7	5.0	0.48	2.7
25	4.8	1.02	3.6	5.2	0.28	3.2	5.2	0.30	3.4	6.2	0.60	3.4
30	5.8	1.23	4.4	6.2	0.33	3.9	6.3	0.36	4.1	7.4	0.72	4.1
35	6.8	1.44	5.1	7.2	0.39	4.5	7.3	0.42	4.8	8.7	0.84	4.8
40	7.7	1.64	5.8	8.3	0.44	5.2	8.4	0.48	5.4	9.9	0.96	5.4
Green Fodders	**Green Oat Fodder, 1:8.7**			**Green Rye Fodder, 1:7.2**			**Green Hungarian, 1:8.7**			**Oats and Peas, 1:4.2**		
2½	0.9	0.06	0.5	0.6	0.05	0.4	0.7	0.05	0.4	0.5	0.07	0.3
5	1.9	0.12	1.0	1.2	0.11	0.7	1.4	0.10	0.8	1.1	0.14	0.5
10	3.8	0.24	2.1	2.3	0.21	1.5	2.9	0.20	1.7	2.1	0.27	1.1
15	5.7	0.36	3.1	3.5	0.32	2.3	4.3	0.30	2.6	3.2	0.41	1.7
20	7.6	0.48	4.2	4.7	0.42	3.0	5.8	0.40	3.5	4.3	0.54	2.3
25	9.5	0.60	5.2	5.9	0.52	3.8	7.2	0.50	4.3	5.3	0.68	2.9
30	11.3	0.72	6.2	7.0	0.63	4.5	8.7	0.60	5.2	6.4	0.81	3.4
35	13.2	0.84	7.3	8.2	0.74	5.3	10.1	0.70	6.1	7.5	0.95	4.0
40	15.1	0.96	8.3	9.4	0.84	6.0	11.6	0.80	6.9	8.5	1.08	4.6

Pounds of Fodder	Total dry matter	Protein	Carbohy-drates, etc.	Total dry matter	Protein	Carbohy-drates, etc.	Total dry matter	Protein	Carbohy-drates, etc.	Total dry matter	Protein	Carbohy-drates, etc.
Green Fodders	**Barley and Peas, 1:3.2**			**Red Clover (green), 1:5.7**			**Alsike Clover (green), 1:5.8**			**Green Clover Rowen, 1:4.2**		
2½	0.5	0.07	0.2	0.7	0.07	0.4	0.6	0.07	0.3	0.6	0.07	0.3
5	1.0	0.14	0.4	1.5	0.15	0.8	1.3	0.13	0.7	1.3	0.14	0.6
10	2.1	0.28	0.9	2.9	0.29	1.6	2.5	0.26	1.4	2.5	0.29	1.2
15	3.1	0.42	1.4	4.4	0.44	2.5	3.8	0.39	2.1	3.8	0.44	1.6
20	4.1	0.56	1.8	5.9	0.58	3.3	5.0	0.52	2.8	5.0	0.58	2.4
25	5.2	0.70	2.3	7.3	0.73	4.1	6.3	0.65	3.5	6.3	0.73	3.0
30	6.2	0.84	2.7	8.8	0.87	4.9	7.6	0.78	4.2	7.5	0.87	3.6
35	7.2	0.98	3.2	10.2	1.02	5.7	8.8	0.91	4.9	8.8	1.02	4.2
40	8.2	1.12	3.6	11.7	1.16	6.6	10.1	1.04	5.6	10.0	1.16	4.8
Silages	**Corn Silage (mature), 1:14.8**			**Corn Silage (immature), 1:14.6**			**Corn Stover Silage, 1:16.6**			**Clover Silage, 1:4.7**		
2½	0.7	0.03	0.4	0.5	0.02	0.3	0.5	0.02	0.3	0.7	0.07	0.3
5	1.3	0.06	0.8	1.0	0.05	0.6	1.0	0.03	0.5	1.4	0.14	0.6
10	2.6	0.12	1.8	2.1	0.09	1.3	1.9	0.06	1.0	2.8	0.27	1.3
15	3.9	0.18	2.7	3.1	0.14	1.9	2.9	0.09	1.5	4.2	0.41	1.9
20	5.3	0.24	3.6	4.2	0.18	2.6	3.9	0.12	2.0	5.6	0.54	2.6
25	6.6	0.30	4.5	5.2	0.23	3.2	4.8	0.15	2.5	7.0	0.68	3.2
30	7.9	0.36	5.3	6.3	0.27	3.9	5.8	0.18	3.0	8.4	0.81	3.9
35	9.2	0.42	6.2	7.3	0.32	4.5	6.8	0.21	3.5	9.8	0.95	4.5
40	10.5	0.48	7.1	8.4	0.36	5.2	7.7	0.24	4.0	11.2	1.08	5.1
Roots	**Potatoes, 1:17.3**			**Beets, 1:6.5**			**Sugar Beets, 1:6.8**			**Carrots, 1:9.6**		
2½	0.5	0.02	0.4	0.3	0.04	0.2	0.3	0.04	0.3	0.3	0.03	0.2
5	1.1	0.05	0.8	0.6	0.07	0.5	0.7	0.08	0.5	0.5	0.05	0.5
10	2.1	0.09	1.6	1.2	0.14	0.9	1.4	0.16	1.1	1.1	0.10	1.0
15	3.2	0.14	2.3	1.7	0.21	1.4	2.0	0.24	1.7	1.6	0.15	1.4
20	4.2	0.18	3.1	2.3	0.28	1.8	2.7	0.32	2.2	2.3	0.20	1.9
25	5.3	0.23	3.9	2.9	0.35	2.3	3.4	0.40	2.7	2.9	0.25	2.4
30	6.3	0.27	4.7	3.5	0.42	2.7	4.1	0.48	3.3	3.4	0.30	2.9
35	7.4	0.32	5.4	4.0	0.49	3.2	4.7	0.56	3.8	4.0	0.35	3.4
40	8.4	0.36	6.2	4.6	0.56	3.6	5.4	0.64	4.4	4.6	0.40	3.8
Roots and Milk	**Mangel Wurtzels, 1:4.9**			**Ruta-bagas, 1:8.6**			**Turnips, 1:7.7**			**Skim Milk, 1:2.0**		
2½	0.2	0.03	0.1	0.3	0.03	0.2	0.2	0.03	0.2	0.2	0.07	0.1
5	0.4	0.06	0.3	0.5	0.05	0.4	0.5	0.05	0.4	0.5	0.15	0.3
10	0.9	0.11	0.5	1.1	0.10	0.9	1.0	0.10	0.8	0.9	0.29	0.6
15	1.4	0.17	0.8	1.6	0.15	1.3	1.4	0.15	1.2	1.4	0.44	0.9
20	1.8	0.22	1.1	2.3	0.20	1.7	1.9	0.20	1.5	1.9	0.58	1.2
25	2.3	0.28	1.4	2.9	0.25	2.2	2.4	0.25	1.9	2.4	0.73	1.6
30	2.7	0.33	1.6	3.4	0.30	2.6	2.9	0.30	2.3	2.8	0.87	1.8
35	3.2	0.39	1.9	4.0	0.35	3.0	3.3	0.35	2.7	3.2	1.02	2.1
40	3.6	0.44	2.2	4.6	0.40	3.4	3.8	0.40	3.1	3.7	1.16	2.4

Pounds of Fodder	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.
Milk	**Buttermilk, 1:1.7**			**Whey, 1:8.7**								
2½	0.2	0.10	0.2	0.2	0.02	0.1	....	....	....	....	....	....
5	0.5	0.19	0.3	0.3	0.03	0.3	....	....	....	....	....	....
10	1.0	0.38	0.6	0.6	0.06	0.5	....	....	....	....	....	....
15	1.5	0.57	1.0	0.9	0.09	0.8	....	....	....	....	....	....
20	2.0	0.76	1.3	1.2	0.12	1.0	....	....	....	....	....	....
25	2.5	0.95	1.6	1.5	0.15	1.3	....	....	....	....	....	....
30	3.0	1.14	1.9	1.9	0.18	1.6	....	....	....	....	....	....
35	3.5	1.33	2.2	2.2	0.21	1.8	....	....	....	....	....	....
40	4.0	1.52	2.6	2.5	0.24	2.1	....	....	....	....	....	....
Hays	**Mixed Hay, 1:10.0**			**Timothy Hay, 1:16.5**			**Red Top Hay, 1:10.3**			**Kentucky Blue Grass Hay, 1:10.6**		
2½	2.1	0.11	1.1	2.2	0.07	1.2	2.3	0.12	1.2	1.9	0.09	1.0
5	4.2	0.22	2.2	4.3	0.14	2.3	4.6	0.24	2.4	3.7	0.19	2.0
7½	6.4	0.33	3.3	6.5	0.21	3.5	6.8	0.36	3.6	5.6	0.28	3.0
10	8.5	0.44	4.4	8.7	0.28	4.6	9.1	0.48	4.9	7.4	0.37	3.9
12½	10.6	0.55	5.5	10.9	0.35	5.8	11.4	0.60	6.2	9.2	0.46	4.9
15	12.7	0.66	6.6	13.0	0.42	6.9	13.9	0.72	7.4	11.1	0.56	5.9
17½	14.8	0.77	7.7	15.2	0.49	8.1	16.0	0.84	8.6	13.0	0.65	6.9
20	16.9	0.88	8.8	17.4	0.56	9.2	18.2	0.96	9.8	14.8	0.74	7.9
25	21.2	1.10	11.0	21.7	0.70	11.6	22.8	1.20	12.3	18.5	0.93	9.9
Hays and Dry Fodder	**Rowen Hay (mixed), 1:5.6**			**Rowen Hay (fine), 1:4.7**			**Alfalfa Hay, 1:3.8**			**Corn Fodder, 1:14.3**		
2½	2.1	0.20	1.1	2.2	0.24	1.1	2.3	0.28	1.1	1.4	0.06	0.9
5	4.2	0.40	2.3	4.3	0.49	2.3	4.6	0.55	2.1	2.9	0.13	1.8
7½	6.3	0.60	3.4	6.5	0.73	3.4	6.9	0.83	3.2	4.3	0.19	2.7
10	8.3	0.80	4.5	8.7	0.97	4.6	9.2	1.10	4.2	5.8	0.25	3.6
12½	10.4	1.00	5.6	10.9	1.21	5.7	11.5	1.38	5.3	7.2	0.32	4.5
15	12.5	1.20	6.7	13.0	1.46	6.8	13.7	1.65	6.4	8.7	0.38	5.4
17½	14.6	1.40	7.8	15.2	1.70	8.0	16.0	1.93	7.4	10.1	0.44	6.2
20	16.7	1.60	8.9	17.4	1.94	9.1	18.3	2.20	8.5	11.6	0.50	7.1
25	20.9	2.00	11.2	21.7	2.43	11.4	22.9	2.75	10.6	14.5	0.63	8.9
Dry Fodders and Hays	**Corn Stover, 1:23.6**			**Oat Hay, 1:9.9**			**Oat and Pea Hay, 1:4.9**			**Hungarian, 1:10.0**		
2½	1.5	0.04	0.8	2.3	0.10	1.0	2.2	0.28	1.2	2.1	0.12	1.2
5	3.0	0.07	1.7	4.6	0.21	2.0	4.4	0.56	2.3	4.2	0.25	2.4
7½	4.5	0.11	2.5	6.8	0.31	3.0	6.6	0.84	3.5	6.3	0.37	3.6
10	6.0	0.14	3.3	9.1	0.41	4.0	8.9	1.12	4.6	8.4	0.49	4.9
12½	7.5	0.18	4.1	11.4	0.51	5.1	11.1	1.40	5.8	10.4	0.62	6.2
15	9.0	0.21	5.0	13.7	0.62	6.1	13.3	1.68	6.9	12.5	0.74	7.4
17½	10.5	0.25	5.8	16.0	0.72	7.1	15.5	1.96	8.1	14.6	0.86	8.6
20	12.0	0.28	6.6	18.2	0.82	8.1	17.7	2.24	9.2	16.7	0.98	9.8
25	15.0	0.35	8.3	22.8	1.03	10.2	22.1	2.80	11.6	20.9	1.23	12.8

Pounds of Fodder or Feed	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.
Hays and Straw	**Red Clover Hay, 1:5.9**			**Alsike Clover Hay, 1:5.5**			**Clover Rowen Hay, 1:4.9**			**Barley Straw, 1:61.0**		
2½	2.1	0.18	1.0	2.3	0.21	1.2	2.3	0.21	1.0	2.1	0.02	1.1
5	4.2	0.36	2.1	4.5	0.42	2.3	4.6	0.43	2.1	4.3	0.04	2.1
7½	6.4	0.53	3.2	6.8	0.63	3.5	6.9	0.64	3.2	6.4	0.05	3.2
10	8.5	0.71	4.2	9.0	0.84	4.6	9.2	0.85	4.2	8.6	0.07	4.3
12½	10.6	0.89	5.2	11.3	1.05	5.8	11.5	1.07	5.2	10.7	0.09	5.3
15	12.7	1.07	6.3	13.5	1.26	6.9	13.8	1.28	6.3	12.9	0.11	6.4
17½	14.8	1.24	7.3	15.8	1.47	8.1	16.0	1.49	7.3	15.0	0.12	7.5
20	16.9	1.42	8.3	18.1	1.68	9.2	18 3	1.70	8.3	17.2	0.14	8.5
25	21.2	1.78	10.5	22.6	2.10	11.6	22.9	2.13	10.5	21.5	0.18	10.7
Straws	**Oat Straw, 1:38.3**			**Wheat Straw, 1:93.0**			**Rye Straw, 1:69.0**					
2½	2.3	0.03	1.2	2.3	0.01	0.9	2.3	0.02	1.0	....	....	....
5	4.6	0.06	2.3	4.5	0.02	1.9	4.6	0.03	2.1	....	....	....
7½	6.8	0.09	3.5	6.8	0.03	2.8	7.0	0.05	3.1	....	....	....
10	9.1	0.12	4.6	9.0	0.04	3.7	9.3	0.06	4.1	....	....	....
12½	11.4	0.15	5.8	11.3	0.05	4.6	11.6	0.08	5.2	....	....	....
15	13.9	0.18	6.9	13.5	0.06	5.6	13.9	0.09	6.2	....	....	....
17½	16.0	0.21	8.1	15.8	0.07	6.5	16.3	0.11	7.2	....	....	....
20	18.2	0.24	9.2	18.1	0.08	7.4	18.6	0.12	8.3	....	....	....
25	22.7	0.30	11.5	22.6	0.10	9.3	23.2	0.15	10.4	....	....	....
Grains	**Corn Meal, 1:11.3**			**Corn and Cob Meal, 1:13.9**			**Oats, 1:6.2**			**Provender (½ ½) 1:8.4**		
¼	0.2	0.02	0.2	0.2	0.01	0.2	0.2	0.02	0.1	0.2	0.02	0.2
½	0.4	0.03	0.4	0.4	0.02	0.3	0.4	0.05	0.3	0.4	0.04	0.3
1	0.9	0.06	0.7	0.9	0.05	0.7	0.9	0.09	0.6	0.9	0.08	0.6
2	1.7	0.13	1.4	1.7	0.10	1.3	1.8	0.18	1.1	1.7	0.15	1.3
3	2.6	0.19	2.1	2.6	0.14	2.0	2.7	0.28	1.7	2.6	0.23	1.9
4	3.4	0.25	2.9	3.4	0.19	2.7	3.6	0.37	2.3	3.5	0.31	2.6
5	4.3	0.32	3.6	4.3	0.24	3.4	4.5	0.46	2.8	4.4	0.39	3.2
7½	6.4	0.48	5.4	6.4	0.36	5.1	6.7	0.69	4.3	6.5	6.58	4.9
10	8.5	0.63	7.1	8.5	0 48	6.7	8.9	0.92	5.7	8.7	0.77	6.5
Grains and By-products	**Provender (as sold in New England), 1:9.4**			**Oat Hulls, 1:18.2**			**Quaker Dairy Feed, 1:4.6**			**H. O. Dairy Feed, 1:3.8**		
¼	0.2	0.02	0.2	0.2	0.01	0.1	0.2	0.03	0.1	0.2	0.04	0.1
½	0.4	0.03	0.3	0.5	0.02	0.3	0.5	0.05	0.3	0.5	0.07	0.2
1	0.9	0.07	0.6	0.9	0.03	0.5	0.9	0.11	0.5	0.9	0.15	0.5
2	1.8	0.14	1.3	1.9	0.05	0.9	1.8	0.22	1.0	1.8	0.29	1.0
3	2.7	0.20	1.9	2.8	0.08	1.4	2.8	0.33	1.5	2.7	0.44	1.5
4	3.5	0.27	2.5	3.7	0.10	1.9	3.7	0.44	2.0	3.6	0.59	2.0
5	4.4	0.34	3.2	4.6	0.13	2.4	4.6	0.55	2.5	4.6	0.74	2.5
7½	6.6	0.51	4.8	7.0	0.20	3.5	6.9	0.82	3.8	6.8	1.10	3.7
10	8.8	0.68	6.4	9.3	0.26	4.7	9.2	1.09	5.0	9.1	1.47	4.9

Pounds of Feed	Total dry matter	Protein	Carbohy-drates, etc.	Total dry matter	Protein	Carbohy-drates, etc.	Total dry matter	Protein	Carbohy-drates, etc.	Total dry matter	Protein	Carbohy-drates, etc.
By-products, etc.	**Victor Corn and Oat Feed, 1:10.1**			**H. O. Horse 1:6.4**			**Barley, 1:8.0**			**Barley Screenings, 1:7.7**		
¼	0.2	0.02	0.2	0.2	0.02	0.1	0.2	0.02	0.2	0.2	0.02	0.2
½	0.5	0.03	0.3	0.5	0.05	0.3	0.4	0.04	0.3	0.4	0.04	0.3
1	0.9	0.06	0.6	0.9	0.09	0.6	0.9	0.09	0.7	0.9	0.09	0.7
2	1.8	0.13	1.3	1.8	0.18	1.2	1.8	0.17	1.4	1.8	0.17	1.3
3	2.7	0.19	1.9	2.7	0.28	1.8	2.7	0.26	2.1	2.6	0.26	2.0
4	3.6	0.25	2.5	3.6	0.37	2.4	3.6	0.35	2.8	3.5	0.34	2.7
5	4.5	0.32	3.2	4.5	0.46	2.9	4.5	0.44	3.5	4.4	0.43	3.3
7½	6.8	0.47	4.8	6.8	0.69	4.4	6.7	0.65	5.2	6.6	0.65	5.0
10	9.0	0.63	6.4	9.0	0.92	5.9	8.9	0.87	6.9	8.8	0.86	6.6
By-products	**Wheat Bran, 1:3.8**			**Wheat Middlings, 1:4.6**			**Wheat Screenings, 1:5.2**			**Mixed (Wheat Feed), 1:3.9**		
¼	0.2	0.03	0.1	0.2	0.03	0.1	0.2	0.02	0.1	0.2	0.03	0.1
½	0.4	0.06	0.2	0.4	0.06	0.3	0.4	0.05	0.2	0.4	0.07	0.3
1	0.9	0.12	0.5	0.9	0.13	0.6	0.9	0.10	0.5	0.9	0.13	0.5
2	1.8	0.24	1.0	1.8	0.25	1.2	1.8	0.20	1.0	1.8	0.27	1.0
3	2.6	0.36	1.4	2.6	0.38	1.7	2.7	0.29	1.5	2.7	0.40	1.5
4	3.5	0.48	1.8	3.5	0.50	2.3	3.5	0.39	2.0	3.6	0.53	2.1
5	4.4	0.60	2.3	4.4	0.63	2.9	4.4	0.49	2.5	4.5	0.67	2.6
7½	6.6	0.90	3.4	6.6	0.94	4.4	6.6	0.74	3.8	6.7	1.00	3.8
10	8.8	1.20	4.6	8.8	1.25	5.8	8.8	0.98	5.1	8.9	1.33	5.2
By-products, etc.	**Red-Dog Flour, 1:3.3**			**Rye, 1:7.8**			**Rye Bran, 1:5.1**			**Cottonseed Meal, 1:1.0**		
¼	0.2	0.04	0.1	0.2	0.02	0.2	0.2	0.03	0.2	0.2	0.10	0.1
½	0.5	0.09	0.3	0.4	0.04	0.3	0.4	0.06	0.3	0.5	0.20	0.2
1	0.9	0.18	0.6	0.9	0.09	0.7	0.9	0.12	0.6	0.9	0.40	0.4
2	1.8	0.36	1.2	1.8	0.18	1.4	1.8	0.25	1.3	1.8	0.80	0.8
3	2.7	0.53	1.7	2.7	0.27	2.1	2.7	0.37	1.9	2.8	1.20	1.2
4	3.6	0.71	2.3	3.5	0.36	2.8	3.5	0.49	2.5	3.7	1.60	1.6
5	4.6	0.89	2.9	4.4	0.46	3.5	4.4	0.62	3.1	4.6	2.00	2.0
7½	6.8	1.34	4.4	6.6	0.67	5.2	6.6	0.92	4.7	6.9	3.00	3.0
10	9.1	1.78	5.8	8.8	0.89	6.9	8.8	1.23	6.3	9.2	4.00	4.0
By-products	**Cottonseed Feed, 1:5.6**			**Cottonseed Hulls, ...**			**Linseed Meal (O. P.), 1:1.5**			**Linseed Meal (N. P.), 1:1.3**		
¼	0.2	0.02	0.1	0.2	....	0.1	0.2	0.08	0.1	0.2	0.08	0.1
½	0.4	0.04	0.2	0.4	....	0.2	0.5	0.15	0.2	0.4	0.16	0.2
1	0.9	0.08	0.4	0.9	....	0.4	0.9	0.31	0.5	0.9	0.32	0.4
2	1.8	0.16	0.9	1.8	....	0.7	1.8	0.62	1.0	1.8	0.65	0.8
3	2.7	0.24	1.3	2.7	....	1.1	2.7	0.92	1.4	2.7	0.97	1.3
4	3.5	0.32	1.8	3.6	....	1.5	3.6	1.23	1.8	3.6	1.30	1.7
5	4.4	0.40	2.2	4.5	....	1.8	4.9	1.54	2.3	4.5	1.62	2.1
7½	6.6	0.59	3.3	6.7	....	2.7	6.8	2.31	3.4	6.7	2.43	3.2
10	8.8	0.79	4.4	8.9	....	3.7	9.0	3.08	4.6	8.9	3.24	4.2

Pounds of Feed	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.	Total dry matter	Protein	Carbohydrates, etc.
By-products	**Flax Meal, 1:1.4**			**Gluten Meal (Chicago), 1:1.5**			**Gluten Meal (Cream), 1:1.7**			**Gluten Meal (King), 1:1.9**		
¼	0.2	0.08	0.1	0.2	0.08	0.1	0.2	0.07	0.1	0.2	0.07	0.1
½	0.4	0.16	0.2	0.4	0.16	0.2	0.4	0.15	0.2	0.5	0.15	0.3
1	0.9	0.32	0.4	0.9	0.32	0.5	0.9	0.30	0.5	0.9	0.30	0.6
2	1.8	0.64	0.9	1.8	0.64	0.9	1.8	0.59	1.0	1.9	0.59	1.1
3	2.7	0.96	1.3	2.6	0.96	1.4	2.7	0.89	1.5	2.8	0.89	1.7
4	3.6	1.28	1.7	3.5	1.28	1.9	3.6	1.19	2.1	3.7	1.19	2.3
5	4.5	1.60	2.2	4.4	1.60	2.3	4.5	1.49	2.6	4.6	1.49	2.8
7½	6.7	2.40	3.3	6.6	2.40	3.5	6.7	2.23	3.9	6.9	2.23	4.3
10	8.9	3.21	4.3	8.8	3.21	4.7	9.0	2.97	5.1	9.3	2.97	5.7
By-products	Gluten Feed (Buffalo or Marshalitown) 1:2.4			Gluten Feed (Diamond or Rockford), 1:3.0			**Hominy Chop, 1:9.2**			**Starch Feed, wet, 1:4.9**		
¼	0.2	0.06	0.1	0.2	0.05	0.2	0.2	0.02	0.2	0.1	0.01	0.1
½	0.4	0.12	0.3	0.5	0.10	0.3	0.5	0.04	0.4	0.2	0.03	0.2
1	0.9	0.23	0.6	0.9	0.20	0.6	0.9	0.09	0.8	0.3	0.05	0.3
2	1.8	0.47	1.1	1.8	0.41	1.2	1.8	0.17	1.6	0.7	0.11	0.5
3	2.7	0.70	1.7	2.7	0.61	1.9	2.8	0.26	2.4	1.0	0.16	0.8
4	3.6	0.93	2.3	3.6	0.81	2.5	3.7	0.35	3.2	1.4	0.22	1.1
5	4.5	1.17	2.8	4.6	1.02	3.1	4.6	0.44	4.0	1.7	0.27	1.3
7½	6.8	1.75	4.3	6.8	1.52	4.7	6.9	0.65	6.0	2.6	0.41	1.7
10	9.0	2.33	5.7	9.1	2.03	6.2	9.2	0.87	8.0	3.5	0.54	2.6
By-products	**Dried Brewers' Grains, 1:3.0**			**Atlas Gluten Meal, 1:2.6**			**Malt Sprouts, 1:2.2**			**Pea Meal, 1:3.2**		
¼	0.2	0.04	0.1	0.2	0.06	0.2	0.2	0.05	0.1	0.2	0.04	0.1
½	0.5	0.08	0.3	0.5	0.12	0.3	0.4	0.09	0.2	0.4	0.08	0.3
1	0.9	0.16	0.5	0.9	0.25	0.6	0.9	0.19	0.4	0.9	0.17	0.5
2	1.8	0.31	0.9	1.8	0.49	1.3	1.8	0.37	0.8	1.8	0.33	1.1
3	2.8	0.47	1.4	2.8	0.74	1.9	2.7	0.56	1.2	2.7	0.50	1.6
4	3.7	0.63	1.9	3.7	0.98	2.6	3.6	0.74	1.6	3.6	0.67	2.1
5	4.6	0.79	2.4	4.6	1.23	3.2	4.5	0.93	2.0	4.5	0.84	2.7
7½	6.9	1.18	3.5	6.9	1.85	4.9	6.7	1.40	3.0	6.7	1.26	4.0
10	9.2	1.57	4.7	9.2	2.46	6.5	9.0	1.86	4.0	9.0	1.68	5.3

AMOUNT OF NUTRIENTS FOR A DAY'S FEEDING.

Standard	Animal	Live weight	Total dry matter	Digestible nutrients: Protein	Carbo-hydrates	Fat	Nutritive ratio*
	Oxen	lbs.	lbs.	lbs.	lbs.	lbs.	
Wolff-Lehmann	At rest in stall....	1000	18.	0.7	8.	0.1	1:11.8
	Fattening Cattle						
Wolff-Lehmann	First period	1000	30.	2.5	15.	0.5	1: 6.5
"	Second period	1000	30.	3.0	14.5	0.7	1: 5.4
"	Third period	1000	26.	2.7	15.	0.7	1: 6.2
	Dairy Cows						
	Milch cows, producing 16 lbs. of milk per day	1000	27.	2.0	11.	0.4	1: 6.0
	Horses						
Wolff-Lehmann	Light work	1000	20.	1.5	9.	0.4	1: 7.0
"	Medium work	1000	24.	2.0	11.5	0.6	1: 6.2
"	Heavy work	1000	26.	2.5	13.3	0.8	1: 6.0
	Growing Cattle Dairy breeds (Age in months)						
Wolff-Lehmann	2–3	150	3.5	0.60	1.95	0.300	1:4.5
"	3–6	300	7.2	0.90	3.84	0.300	1:5.1
"	6–12	500	13.5	1.00	6.25	0.250	1:6.8
"	12–18	700	18.2	1.26	8.75	0.280	1:7.5
"	18–24	900	23.4	1.35	10.80	0.270	1:8.5
	Beef breeds						
Wolff-Lehmann	2–3	160	3.7	0.67	2.08	0.320	1:4.2
"	3–6	330	7.9	1.16	4.22	0.495	1:4.7
"	6–12	550	13.8	1.38	7.26	0.385	1:6.0
"	12–18	750	18.0	1.50	9.38	0.375	1:6.7
"	18–24	950	22.8	1.71	11.40	0.380	1:7.2
	Growing Sheep Wool breeds						
Wolff-Lehmann	4–6	60	1.5	0.20	0.92	0.042	1:5.0
"	6–8	75	1.9	0.21	1.04	0.045	1:5.4
"	8–11	80	1.8	0.17	0.92	0.040	1:6.0
"	11–15	90	2.0	0.16	1.01	0.036	1:7.0
"	15–20	100	2.2	0.15	1.08	0.030	1:7.7
	Mutton breeds						
Wolff-Lehmann	4–6	60	1.6	0.26	0.93	0.054	1:4.0
"	6–8	80	2.1	0.28	1.20	0.056	1:4.8
"	8–11	100	2.4	0.30	1.43	0.050	1:5.2
"	11–15	120	2.8	0.26	1.51	0.060	1:6.3
"	15–20	150	3.3	0.30	1.80	0.060	1:6.5

* The nutritive ratio is obtained by multiplying the number of pounds of fat by 2¼, adding the product to the number of pounds of carbohydrates, and dividing this sum by the number of pounds of protein.

Standard	Animal	Live weight	Total dry matter	Digestible nutrients: Protein	Digestible nutrients: Carbo-hydrates	Digestible nutrients: Fat	Nutritive ratio
	Growing Swine Breeding stock (Age in months)	lbs.	lbs.	lbs.	lbs.	lbs.	
Wolff-Lehmann	2–3	50	2.2	0.38	1.40	0.050	1:4.0
"	3–5	100	3.5	0.50	2.31	0.080	1:5.0
"	5–6	120	3.8	0.44	2.56	0.048	1:6.0
"	6–8	200	5.6	0.56	3.74	0.060	1:7.0
"	8–12	250	6.3	0.53	3.83	0.050	1:7.5
	Growing fattening Swine						
Wolff-Lehmann	2–3	50	2.2	0.38	1.40	0.050	1:4.0
"	3–5	100	3.5	0.50	2.31	0.080	1:5.0
"	5–6	150	5.0	0.65	3.35	0.090	1:5.5
"	6–8	200	6.0	0.72	4.10	0.080	1:6.0
"	9–12	200	5.2	0.60	3.66	0.060	1:6.4
	Human beings			Protein	Carbohydrates and Fats		
	Children, 6–15 yrs.			0.16	0.93		1:5.2
	Students			0.20	1.11		1:5.5
	Professional Men			0.27	1.76		1:4.7
	Man with moderate work			0.28	1.62		1:5.8
	Man with hard work			0.39	2.67		1:6.9

FERTILIZING CONSTITUENTS IN AMERICAN FEEDING STUFFS.

NAME OF FEED	Fertilizing Constituents in 1,000 Pounds		
	Nitrogen	Phosphoric Acid	Potash
Concentrates	Lbs.	Lbs.	Lbs.
Corn, all analyses	18.2	7.0	4.0
Corn Cob	5.0	.6	6.0
Corn and Cob Meal	14.1	5.7	4.7
Corn Bran	16.3	12.1	6.8
Gluten Meal	50.3	3.3	0.5
Germ Meal	26.5	8.0	5.0
Starch Refuse	22.4	7.0	5.2
Grano-Gluten	49.8	5.1	1.5
Hominy Chops	16.3	9.8	4.9
Sugar Meal	36.3	4.1	0.3
Starch Feed, wet	9.8	1.0	1.0
Wheat	23.6	7.9	5.0
High-grade Flour	18.9	2.2	1.5
Low-grade Flour	28.9	5.6	3.5
Dark Feeding Flour	31.8	21.4	10.9
Wheat Bran	26.7	28.9	16.1
Wheat Shorts	28.2	13.5	5.9
Wheat Middlings	26.3	9.5	6.3
Wheat Screenings	24.4	11.7	8.4
Rye	17.6	8.2	5.4
Rye Bran	23.2	22.8	14.0
Rye Shorts	18.4	12.6	8.1
Barley	15.1	7.9	4.8
Malt Sprouts	35.5	14.3	16.3
Brewers' Grains, wet	8.9	3.1	0.5
Brewers' Grains, dried	36.2	10.3	0.9
Oats	20.6	8.2	6.2
Oat Feed or Shorts	17.2	9.1	5.3
Oat Hulls	5.2	2.4	5.2
Rice	10.8	1.8	0.9
Rice Hulls	5.8	1.7	1.4
Rice Bran	7.1	2.9	2.4
Rice Polish	19.7	26.7	7.1
Buckwheat	14.4	4.4	2.1
Buckwheat Hulls	4.9	0.7	5.2
Buckwheat Bran	36.4	17.8	12.8
Buckwheat Middlings	42.8	21.9	11.4
Sorghum Seed	14.8	8.1	4.2
Millet	20.4	8.5	3.6
Flax Seed	36.1	13.9	10.3
Linseed Meal, old process	54.3	16.6	13.7
Linseed Meal, new process	57.8	18.3	13.9

NAME OF FEED	Fertilizing Constituents in 1,000 Pounds		
	Nitrogen	Phosphoric Acid	Potash
Concentrates — continued	Lbs.	Lbs.	Lbs.
Cotton Seed	31.3	12.7	11.7
Cotton-seed Meal	67.9	28.8	8.7
Cotton-seed Hulls	6.9	2.5	10.2
Cocoanut Meal	32.8	16.0	24.0
Palm-nut Meal	26.9	11.0	5.0
Sunflower Seed	22.8	12.2	5.6
Sunflower-seed Cakes	55.5	21.5	11.7
Peanut Meal	75.6	13.1	15.0
Rape-seed Meal	49.6	20.0	13.0
Peas	30.8	8.2	9.9
Soja (Soy) Bean	53.0	18.7	19.9
Horse Bean	40.7	12.0	12.9
Roughage			
Fodder Corn			
Fodder Corn, green	4.1	1.5	3.3
Fodder Corn, field-cured	17.6	5.4	8.9
Corn Stover, field-cured	10.4	2.9	14.0
Fresh Grass.			
Pasture Grasses (mixed)	9.1	2.3	7.5
Timothy, different stages	4.8	2.6	7.6
Orchard Grass, in bloom	4.3	1.6	7.6
Oat Fodder	4.9	1.3	3.8
Rye Fodder	3.3	1.5	7.3
Sorghum	2.3	0.9	2.3
Hungarian Grass	3.9	1.6	5.5
Hay			
Timothy	12.6	5.3	9.0
Orchard Grass	13.1	4.1	18.8
Redtop	11.5	3.6	10.2
Kentucky Blue Grass	11.9	4.0	15.7
Hungarian Grass	12.0	3.5	13.0
Mixed Grasses	14.1	2.7	15.5
Rowen (mixed)	16.1	4.3	14.9
Meadow Fescue	9.9	4.0	21.0
Soja-bean Hay	23.2	6.7	10.8
Straw			
Wheat	5.9	1.2	5.1.
Rye	4.6	2.8	7.9
Oat	6.2	2.0	12.4
Barley	13.1	3.0	20.9
Wheat Chaff	7.9	7.0	4.2

NAME OF FEED	Fertilizing Constituents in 1,000 Pounds		
	Nitrogen	Phosphoric Acid	Potash
Roughage — continued Fresh Legumes	Lbs.	Lbs.	Lbs.
Red Clover, different stages	5.8	1.8	4.6
Alsike, bloom	4.4	1.1	2.0
Crimson Clover	4.3	1.3	4.9
Alfalfa	7.2	1.3	5.6
Cowpea	2.7	1.0	3.1
Soja Bean	2.9	1.5	5.3
Legume Hay and Straw			
Red Clover, medium	20.7	3.8	22.0
Red Clover, mammoth	22.3	5.5	12.2
Alsike Clover	23.4	6.7	22.3
White Clover	27.5	5.2	18.1
Crimson Clover	20.5	4.0	13.1
Alfalfa	21.9	5.1	16.8
Cowpea	19.5	5.2	14.7
Soja-bean Straw	17.5	4.0	13.2
Pea-vine Straw	14.3	3.5	10.2
Silage			
Corn	2.8	1.1	3.7
Roots and Tubers			
Potato	3.2	1.2	4.6
Beet, common	2.4	0.9	4.4
Beet, sugar	2.2	1.0	4.8
Beet, mangel	1.9	0.9	3.8
Flat Turnip	1.8	1.0	3.9
Ruta-baga	1.9	1.2	4.9
Carrot	1.5	0.9	5.1
Parsnip	1.8	2.0	4.4
Artichoke	2.6	1.4	4.7
Miscellaneous			
Cabbage	3.8	1.1	4.3
Spurry	3.8	2.5	5.9
Sugar-beet Leaves	4.1	1.5	6.2
Pumpkin, garden	1.1	1.6	0.9
Prickly Comfrey	4.2	1.1	7.5
Rape	4.5	1.5	3.6
Dried Blood	135.0	13.5	7.7
Meat Scrap	113,9	7.0	1.0
Dried Fish	77.5	120.0	2.0
Beet Pulp	1.4	0.2	0.4
Beet Molasses	14.6	0.5	56.3
Cows' Milk	5.3	1.9	1.8
Cows' Milk, colostrum	28.2	6.6	1.1
Skim Milk, gravity	5.6	2.0	1.9
Skim Milk, centrifugal	5.6	2.0	1.9
Buttermilk	4.8	1.7	1.6
Whey	1.5	1.4	1.8

NUTRIENTS IN FOOD MATERIALS.

FOOD MATERIALS	Total Dry Matter	Protein	Carbohydrates, etc.
Animal Foods, as Purchased	%	%	%
Beef: Neck	30.4	15.6	31.5
Rib	40.8	12.2	62.8
Sirloin	32.2	15.0	36.9
Round steak	31.3	18.8	27.7
Veal: Shoulder	25.4	16.6	17.8
Animal Foods, Edible Portion			
Beef: Neck	33.0	19.5	39.4
Shoulder	36.1	19.5	35.1
Rib	51.9	15.4	80.1
Sirloin	40.0	18.5	46.1
Round	31.8	20.5	22.7
Rump, corned	41.9	13.3	59.9
Veal: Shoulder	31.2	20.2	22.1
Mutton: Shoulder	41.4	18.1	50.4
Leg	38.2	18.8	42.8
Pork: Shoulder roast, fresh	49.7	16.0	78.8
Ham, salted, smoked	58.5	16.7	88.0
Fat, salted	87.9	0.9	186.3
Chicken	27.8	24.4	4.5
Eggs	26.2	14.9	28.6
Milk	13.0	3.6	18.7
Butter	89.0	1.0	191.8
Cheese: Full-cream	69.8	28.3	81.7
Fish: Codfish	17.4	15.8	0.9
Salmon	36.4	21.6	30.2
Mackerel, salt	....	17.3	59.4
Oysters	12.9	6.0	6.4
Vegetable Foods			
Wheat flour	87.5	11.0	77.4
Graham flour (wheat)	86.9	11.7	75.5
Rye flour	86.9	6.7	80.5
Buckwheat flour	85.4	6.9	79.3
Oatmeal	92.4	15.1	84.1
Cornmeal	85.0	9.2	79.2
Rice	87.6	7.4	80.3
Peas	87.7	26.7	60.2
Beans	87.4	23.1	63.7
Potatoes	21.1	2.1	18.1
Sweet Potatoes	28.9	1.5	26.9
Turnips	10.6	1.2	8.7
Carrots	11.4	1.1	9.8
Onions	12.4	1.4	10.8
String beans	12.8	2.2	10.3
Green peas	21.9	4.4	17.4
Green corn	18.7	2.8	15.7
Tomatoes	4.0	0.8	3.4
Cabbage	8.1	2.1	6.2
Apples	16.8	0.2	16.8
Sugar, granulated	98.0	....	97.8
Molasses	75.4	....	73.1
White bread (wheat)	67.7	8.8	60.1

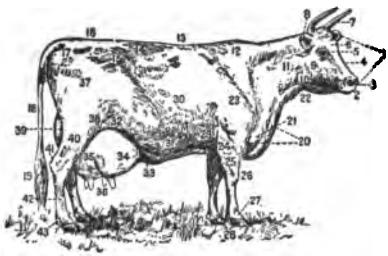


Diagram of Cow.

1. Head.
2. Muzzle.
3. Nostril.
4. Face.
5. Eye.
6. Forehead.
7. Horn.
8. Ear.
9. Cheek.
10. Throat.
11. Neck.
12. Withers.
13. Back.
14. Loins.
15. Hip bone.
16. Pelvic arch.
17. Rump.
18. Tail.
19. Switch.
20. Chest.
21. Brisket.
22. Dewlap.
23. Shoulder.
24. Elbow.
25. Forearm.
26. Knee.
27. Ankle.
28. Hoof.
29. Heart girth.
30. Side or barrel.
31. Belly.
32. Flank.
33. Milk vein.
34. Fore udder.
35. Hind udder.
36. Teats.
37. Upper thigh.
38. Stifle.
39. Twist.
40. Leg or gaskin.
41. Hock.
42. Shank.
43. Dew claw.

1. Head.
2. Face.
3. Muzzle.
4. Nostril.
5. Eye.
6. Ear.
7. Cheek.
8. Neck.
9. Withers.
10. Throat.
11. Back.
12. Loins.
13. Angle of Ilium.
14. Rump.
15. Tail or Dock.
16. Chest.
17. Shoulder.
18. Elbow.
19. Forearm.
20. Knee.
21. Ankle.
22. Claw.
23. Girth Measure.
24. Side or Barrel.
25. Belly.
26. Flank.
27. Hip Joint.
28. Stifle Joint.
29. Hock Joint.

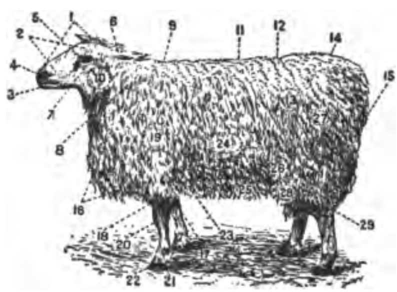


Diagram of Sheep.

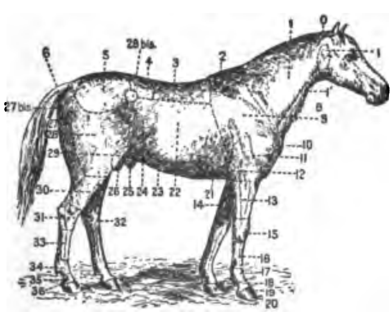


Diagram of Horse.

0. Poll or nape of the neck.
1. Neck.
1'. Jugular gutter.
2. Withers.
3. Back.
4. Loins.
5. Croup.
6. Tail.
7. Parotid region.
8. Throat.
9. Shoulder.
10. Point of the shoulder.
11. Arm.
12. Elbow.
13. Forearm.
14. Chestnut.
15. Knee.
16. Canon.
17. Fetlock.
18. Pastern.
19. Coronet.
20. Foot.
21. Xiphoid region.
22. Ribs.
23. Abdomen.
24. Flank.
25. Sheath.
26. Testicles.
27. Buttock.
27 *bis.* Angle of buttock.
28. Thigh.
28 *bis.* Haunch.
29. Stifle.
30. Leg.
31. Hock.
32. Chestnut.
33. Canon.
34. Fetlock.
35. Pastern.
36. Coronet.

1. Comb.
2. Face.
3. Wattles.
4. Ear-lobes.
5. Hackle.
6. Breast.
7. Back.
8. Saddle.
9. Saddle - feathers.
10. Sickles.
11. Tail-coverts.
12. Main tail feathers.
13. Wing-bow.
14. Wing coverts, forming wing-bar.
15. Secondaries, wing-bay.
16. Primaries or flight feathers; wing-buts.
17. Point of breast bone.
18. Thighs.
19. Hocks.
20. Shanks or legs.
21. Spur.
22. Toes or claws.

Diagram of Chicken.

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